KANSAS-LOWER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Milford Lake

Water Quality Impairment: Eutrophication and Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Republican

Counties: Geary, Cloud, Clay, Riley, Washington, Jewell, Republic, Dickinson

HUC8: 10250017

HUC10 (HUC12):
01 (01, 02, 03, 04, 05, 06, 07)
02 (01, 02, 03, 04, 05)
03 (01, 02, 03, 04, 05, 06, 07, 08, 09, 10)
04 (01, 02, 03, 04, 05, 06, 07, 08, 09)
05 (01, 02, 03, 04, 05, 06, 07, 08)
06 (01, 02, 03, 04, 05, 06, 07, 08, 09)

10250016
07 (08)
08 (01, 02, 03, 04, 05)
09 (01, 02, 03)

Ecoregion: Central Great Plains, Smoky Hills (27a), Flint Hills (28)

Drainage Area: 2,361 square miles in Kansas-Lower Republican Basin

Milford Lake Conservation Pool:

Surface Area = 15,498 acres
Watershed/ Lake Ratio = 98:1
Maximum Depth = 18.0 m
Mean Depth = 7.4 m
Storage Volume = 373,152 acre-feet
Estimated Retention Tim = 0.18 years
Mean Annual Inflow = 497,618 acre-feet (2005-2012)
Mean Annual Outflow = 451,852 acre-feet (2005-2012)
Year Constructed: 1967
Design Sedimentation Rate: 1730 acre-feet/year
Actual Sedimentation Rate: 1007 acre-feet/year

Milford Lake Designated Uses: Expected Aquatic Life; Primary Contact Recreation Class A; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply; Irrigation Use; and Livestock Watering Use.

303(d) Listings: Milford Lake Eutrophication; 2004 and 2012 Kansas-Lower Republican River Basin Lakes.

Dissolved Oxygen; 2002, 2004, 2008, 2010, and 2012 Kansas-Lower Republican River Basin Lakes.

Impaired Use: All uses in Milford Lake are impaired to a degree by eutrophication. Expected Aquatic Life Support is impaired in Milford Lake due to dissolved oxygen deficiencies.

Water Quality Criteria: Nutrients - Narratives: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life (K.A.R. 28-16-28e(c)(2)(A)).

The introduction of plant nutrients into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(c)(3)(A)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (K.A.R. 28-26-28e(c)(7)(A)).

The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. Dissolved Oxygen (DO): 5 mg/L (K.A.R. 28-16-28e(d), Table 1g).

2. CURRENT WATER QUALITY CONDITIONS AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2012-303(d): Excessive nutrients are not being controlled and are thus impairing aquatic life; domestic water supply; and contributing to objectionable algal blooms that contribute to the eutrophication and impairment of contact recreation within Milford Lake.

Level of Eutrophication for Milford Lake:

Recent Average (1996-2012): Fully Eutrophic, Trophic State Index = 57.01
Chlorophyll *a* = 21.4 µg/L

Current Condition (2012): Hypereutrophic, Trophic State Index = 71.98
Chlorophyll *a* = 67.9 µg/L

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll *a* concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic condition is seen with chlorophyll *a* concentrations over 12 µg/l and hypereutrophy occurs at levels over 30 µg/l. The Carlson TSI derives from the chlorophyll *a* concentrations and scales the trophic state as follows:

1. Oligotrophic TSI: <40
2. Mesotrophic TSI: 40-49.99
3. Slightly Eutrophic TSI: 50-54.99
4. Fully Eutrophic TSI: 5-59.99
5. Very Eutrophic TSI: 60-63.99
6. Hypereutrophic TSI: >64

Lake Monitoring Sites: KDHE Station LM019001 in Milford Lake. Period of Record: 15 Surveys conducted by KDHE in calendar years: 1976, 1980, 1982, 1988, 1991, 1994, 1996, 1997, 1998, 2000, 2003, 2006, 2009, 2012. United States Army Corps of Engineers (USACE) select sampling points for years ranging from 1996-2012.

Stream Chemistry Monitoring Sites (Period of Record Used):

Station SC231 Republican River Near Hardy, Nebraska (1990-2012)
Station SC503 Republican River near Clay Center (1990-2012)
Station SC504 Republican River near Clay Center (Rotational) (1990-2012)
Station SC509 Buffalo Cr near Concordia (1990-2012)
Station SC510 Republican River near Rice (1990-2012)
Station SC649 Peats Cr near Clifton (Rotational) (1993-2011)
Station SC650 Salt Cr near Hollis (Rotational) (1993-2009)
Station SC707 Wolf Cr near Concordia (Rotational) (1994-2010)
Station SC709 Elm Cr near Ames (Rotational) (1995-2011)
Station SC710 Mulberry Cr near Clifton (Rotational) (1995-2011)
Station SC711 Five Cr near Clay Center (Rotational) (1996-2012)

Flow Record:

USGS Gage 06853500 Republican R near Hardy, NE (1980-2012)
USGS Gage 06856000 Republican R at Concordia, KS (1980-2012)
USGS Gage 06856600 Republican R at Clay Center, KS (1980-2012)

Table 1. Long Term Flow for the Republican River at USGS Gages (1980-2012).

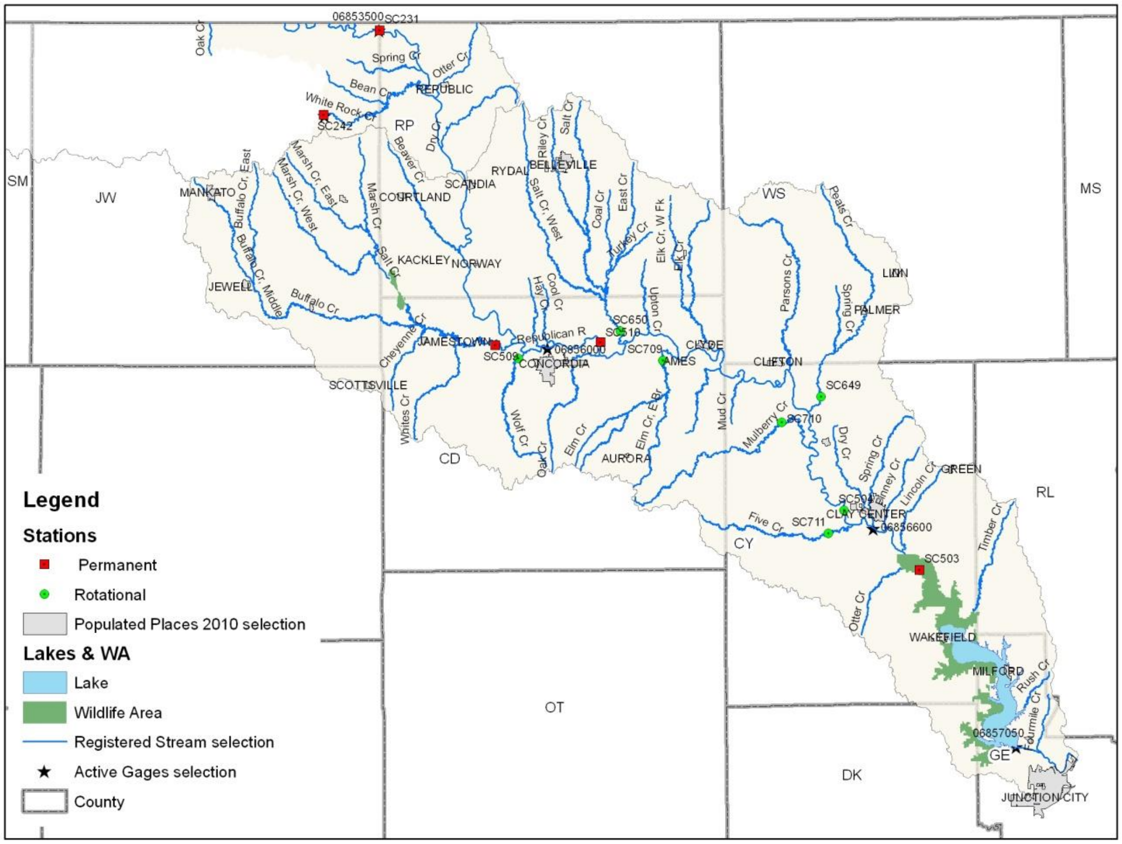
Stream	Average Flow (cfs)	Percent of Flow Exceedance				
		10% (cfs)	25% (cfs)	50% (cfs)	75% (cfs)	90% (cfs)
Republican River near Hardy – Gage 06853500	264.2	563.7	257	144	59	25
Republican River at Concordia – Gage 06856000	475.6	1040	462	234.5	123	51
Republican River at Clay Center – Gage 06856600	762.7	1640	696	333	165	66

Table 2. Long Term Flow Estimates for stream entering Milford Lake as calculated by USGS using multiple regression techniques (Perry, 2004).

Stream (USGS Site ID)	Drainage Area (mi2)	Average Flow (cfs)	Percent of Flow Exceedance				
			10% (cfs)	25% (cfs)	50% (cfs)	75% (cfs)	90% (cfs)
Republican River (1422)	22917.49	911.51	2086.09	919.22	378.48	177.77	102.71
Timber Cr (1476)	58.69	23.19	29.53	10.38	3.26	0.47	0
Rush Cr (1672)	10.86	5.05	5.33	1.67	0.52	0	0

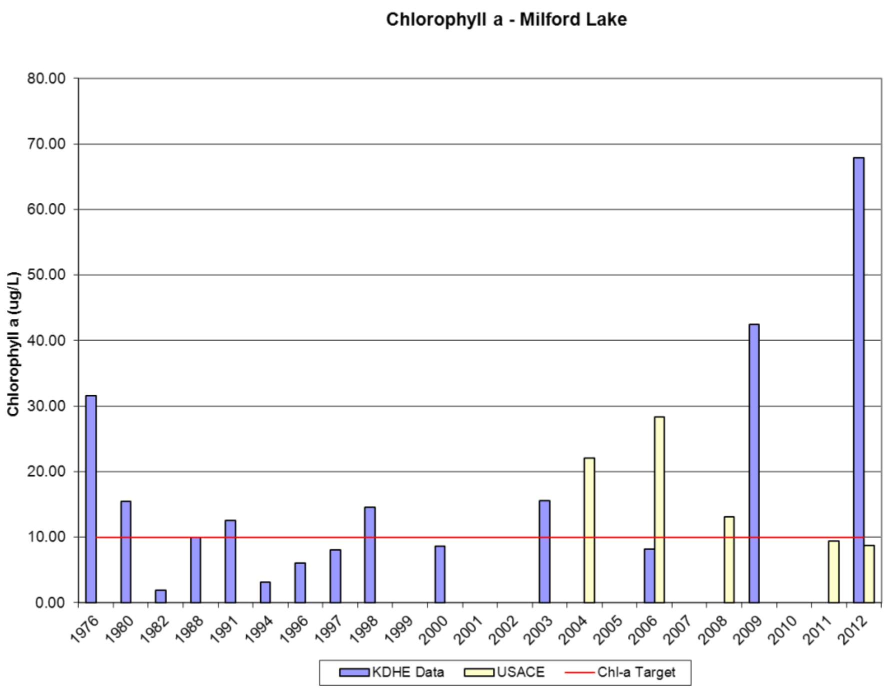
Hydrologic Conditions: Long term flow conditions at USGS Gages in the watershed are detailed in Table 1. Estimated flow conditions for streams entering Milford Lake, as reported by Perry, are detailed in Table 2. According to the USGS Lake Hydro data, the mean runoff in the watershed is 3.3 inches/year and the mean loss due to evaporation for Milford Lake is 52.5 inches/ year. Based on the USACE daily outflow and inflow data for Milford Lake, the calculated mean annual outflow for the lake is 451,852 acre-feet/year. The average annual inflow for the lake is 497,618 acre-feet. The annual mean precipitation for Clay and Geary Counties is 30.1 and 32.1 inches per year respectively (KSU Weather Data Library).

Figure 1. Milford Lake Watershed Base Map.



Current Condition: KDHE sampled the main basin of Milford Lake 15 times over the period of record, with the majority of the sampling events taking place during the summer months of June or July. The chlorophyll *a* concentration average over the entire period of record for KDHE data in Milford Lake is 17.57 µg/L. The more recent chlorophyll *a* concentration average for KDHE samples obtained from 1996-2012 is 21.4 µg/L, which consisted of eight sampling events. The United States Corps of Engineers (USACE) has sampled the main basin of Milford Lake 22 times since 2004. The USACE collected one to six samples between April and September during the years that they sampled the main basin. The USACE samples were averaged out for each sampling year to establish annual averages. The annual average chlorophyll *a* concentration based on the USACE data in Milford Lake is 16.29 µg/L. Utilizing both the KDHE and USACE main basin data, the annual average chlorophyll *a* concentration since 1996 in Milford Lake is 19.45 µg/L. Figure 2 details the average chlorophyll *a* concentrations for each sampling year within Milford Lake.

Figure 2. Average Chlorophyll *a* concentration for the respective years Milford Lake was sampled.



The KDHE average secchi depth in Milford Lake is 1.59 meters, with the lowest reading of 1.0 m observed in 1996. The greatest secchi depth was observed in 2006, with a sechhi depth of 2.42 m. The secchi depth readings obtained by the USACE had an annual average of 1.32 m from 2005-2012. Figure 3 details the annual average secchi depth readings within Milford Lake. The average turbidity value obtained by KDHE in Milford Lake has averaged 5.38 NTU and ranged from 1.8 NTU to 10.45 NTU. The average Total Suspended Solids (TSS) concentration within Milford Lake is 6.52 mg/L for KDHE data and 6.98 mg/L for USACE data over the entire period of record. The average total nitrogen (TN) and total phosphorus (TP) concentrations over the entire period of record are 1.17 mg/L and 0.14 mg/L respectively for the KDHE sampling data. The USACE data yielded annual averages of 1.01 mg/L of TN and 0.20 mg/L of TP. The recent average TN and TP concentrations for the combined data sets since 1996 is 1.05 mg/L and 0.18 mg/L respectively. The maximum TP concentration of 0.31 mg/L was detected in 2005. Data for calculating TN is not available prior to the 1994 sampling event and a maximum TN detection of 1.60 mg/L occurred in 2011. The annual average TP and TN concentrations within Milford Lake are detailed in Figures 4 and 5. A summary of the annual lake concentrations are displayed in Table 3.

The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is likely limiting plant growth in Kansas aquatic ecosystems. Typically, lakes that are nitrogen limited have a water column TN:TP ratio < 8(mass);

and lakes that are co-limited by nitrogen and phosphorus have a TN:TP ratio between 9 and 21; and lakes that are P limited have a water column TN:TP ratio >29 (Dzialowski et. al, (2005). Milford Lake has varied between being nitrogen limited in 1996, 2001, 2002, 2003, 2004, 2005, 2006, 2009, 2010, and 2012; and co-limited by nitrogen and phosphorus in 1994, 1997, 1998, 2000, 2008, and 2011.

Table 3. Concentration averages for the main basin of Milford Lake for KDHE and USACE data for all sampling years.

Sample Year	Source	Chl-a (µg/l)	TN (mg/L)	TP (mg/L)	TN:TP ratio	Secchi (m)	TSS (mg/L)	Turbidity (NTU)
1976	KDHE	31.58					7.00	7.98
1980	KDHE	15.50		0.05			10.00	7.8
1982	KDHE	1.90		0.20			4.25	10.45
1988	KDHE	9.92		0.08			7.00	5
1991	KDHE	12.55				1.90	3.00	2.4
1994	KDHE	3.10	1.35	0.09	15.37	1.30	3.00	2.25
1996	KDHE	6.05		0.13		1.00	5.00	5.45
1996	USACE		0.86	0.28	3.07			
1997	KDHE	8.05	1.09	0.12	9.45	1.10	5.50	3
1997	USACE		1.09	0.18	6			
1998	KDHE	14.55	1.24	0.09	14.21	1.71	4.00	2.95
1998	USACE		1.33	0.17	7.73			
1999	USACE		1.31	0.21	6.35			
2000	KDHE	8.65	1.24	0.14	9.08	1.66	2.50	1.8
2000	USACE		0.84	0.17	4.91			
2001	USACE		0.76	0.19	4.13			
2002	USACE		0.36	0.12	3.10			
2003	KDHE	15.60	0.83	0.12	6.97	1.85	10.00	4.56
2003	USACE		0.38	0.11	3.43			
2004	USACE	22.00	1.06	0.20	5.20			5.83
2005	USACE		1.19	0.31	3.87	0.78	6.50	5.9
2006	KDHE	8.15	0.80	0.14	5.89	2.42	10.00	4.86
2006	USACE	28.30	0.76	0.17	4.51	1.45	4.60	2.07
2007	USACE		1.17	0.20	5.80		20.93	
2008	USACE	13.08	1.29	0.10	12.93	1.19	4.60	
2009	KDHE	42.50	1.37	0.19	7.32	1.46	10.00	9.03
2009	USACE		0.84	0.19	4.45		4.84	2.13
2010	USACE		1.32	0.25	5.28	1.59	4.15	19.95
2011	USACE	9.40	1.60	0.20	7.92	1.10	5.53	
2012	KDHE	67.88	1.44	0.30	4.86	1.50	10.00	7.8
2012	USACE	8.68	0.94	0.28	3.39	1.81	4.72	10.73
KDHE Data Average		17.57	1.17	0.14	9.14	1.59	6.52	5.38
USACE Data Avg.		16.29	1.01	0.20	5.42	1.32	6.98	7.77
All Data Average		17.23	1.06	0.17	6.61	1.49	6.69	6.10
1996- Present Data Average		19.45	1.05	0.18	6.24	1.47	7.05	6.15
1996-Present Data Median		13.08	1.09	0.18	5.54	1.48	5.25	5.16

Figure 3. Milford Lake annual average Secchi Depth readings.

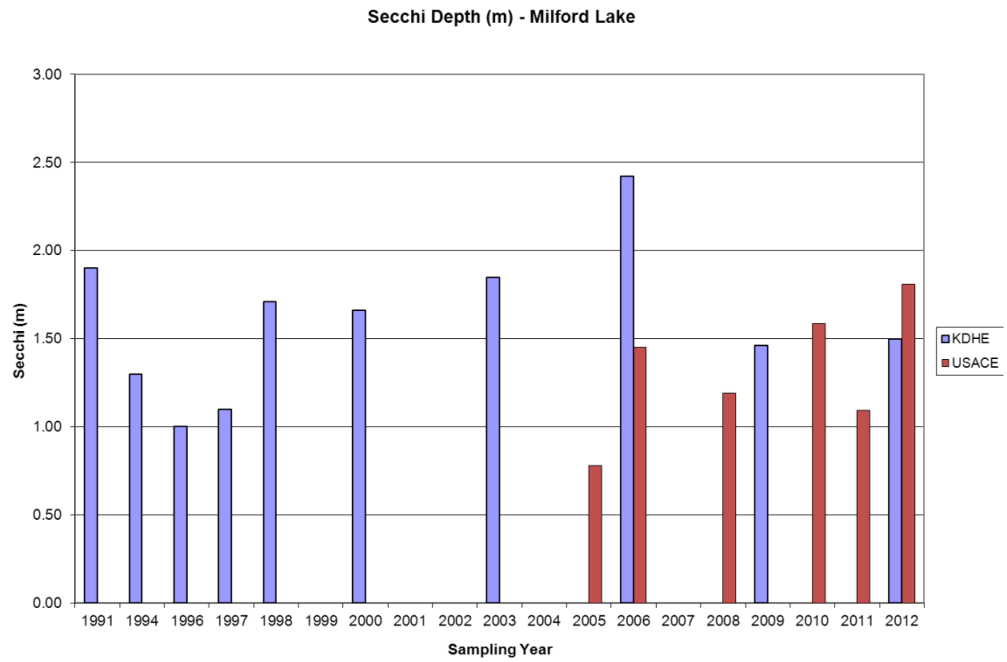


Figure 4. Total Phosphorus Concentrations in Milford Lake for all data

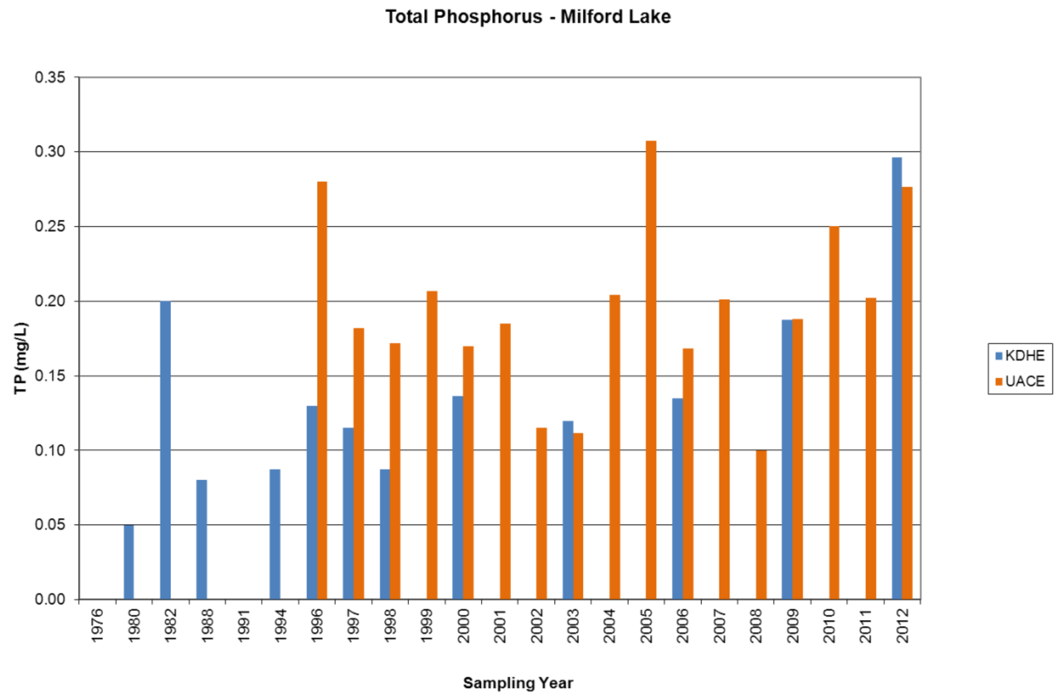


Figure 5. Milford Lake annual average Total Nitrogen Concentrations.

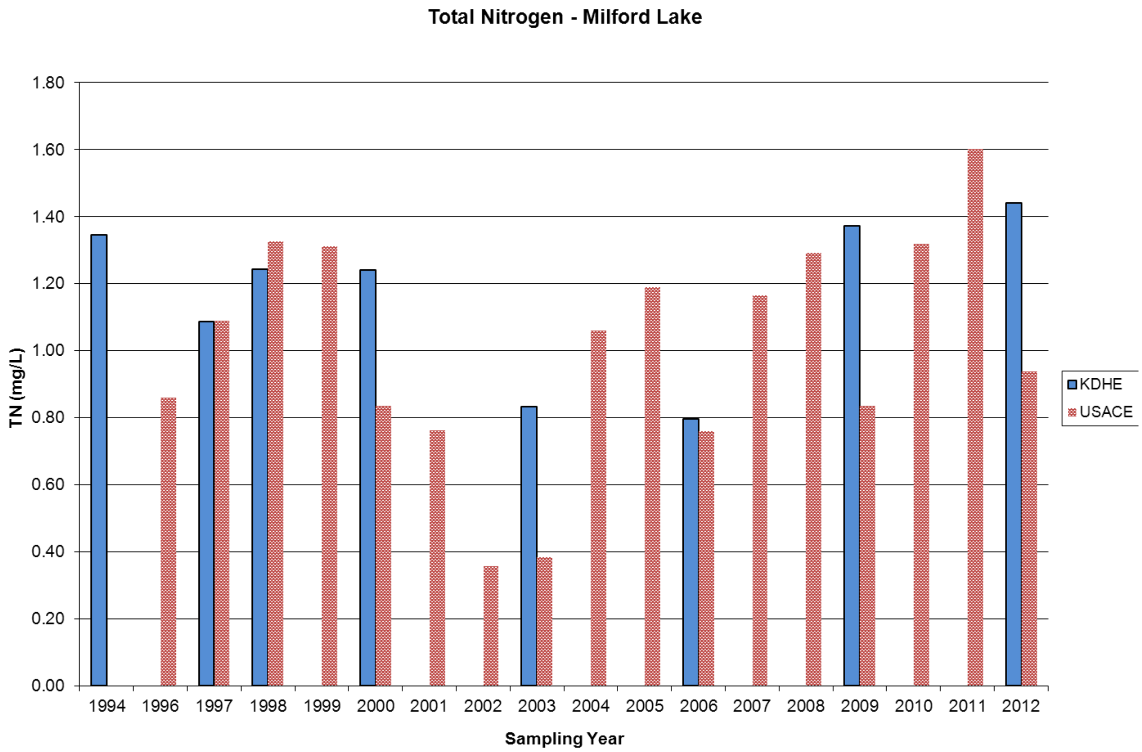


Table 4 lists the six metrics measuring the roles of light and nutrients in Milford Lake. Non-Algal turbidity (NAT) values < 0.4 m^{-1} indicates there are very low levels of suspended silt and/or clay. The values between 0.4 and 1.0 m^{-1} indicate inorganic turbidity assumes greater influence on water clarity but would not assume a significant limiting role until values exceed 1.0 m^{-1}. Milford Lake data indicates there are low levels of suspended silt and/or clay and inorganic turbidity is not assuming a significant limiting role.

The depth of the mixed layer in meters (Zmix) multiplied by the NAT value assesses light availability in the mixed layer. There is abundant light within the mixed layer of the lake and potentially a high response by algae to nutrient inputs when this value is < 3. Values greater than 6 would indicate the opposite. Milford Lake generally does have abundant light within the mixed layer of the lake with the potential for a high response by algae to nutrient inputs. For the three years (1994, 1996, 2011) this value was greater than 3 in Milford Lake, the chlorophyll *a* concentrations have been less than 10 µg/L.

The partitioning of light extinction between algae and non-algal turbidity is expressed as Chl-a*SD (chlorophyll *a* * secchi depth). Inorganic turbidity is not responsible for light extinction in the water column and there is a strong algal response to changes in nutrient levels when this value is > 16. Values < 6 indicate that inorganic turbidity is primarily responsible for light extinction in the water column and there is a weak algal response to changes in nutrient levels. In Milford Lake values are > 16 and the chlorophyll *a* values in the lake are greater than 10 µg/L during the years of 1991, 1998, 2003, 2006, 2009, and 2012. Years with a weak algal response to changes in the nutrient levels are seen in 1994, where the respective chlorophyll *a* average is only 3.1 µg/L.

Values of algal use of phosphorus supply (Chl-a/TP) that are greater than 0.4 indicate a strong algal response to changes in phosphorus levels, where values < 0.13 indicate a limited response by algae to phosphorus. During the years where chlorophyll *a* values are greater than 10 µg/L, Milford Lake has a strong algal response to changes in phosphorus levels.

The light availability in the mixed layer for a given surface light is represented as Zmix/SD. Values < 3 indicate that light availability is high in the mixed zone and there is a high probability of strong algal responses to changes in nutrient levels. Most years at Milford Lake, the Zmix/SD values are > 3.

Shading values less than 16 indicate that self-shading of algae does not significantly impede productivity. This metric is most applicable to lakes with maximum depths of less than 5 meters (Carney, 2004). Milford Lake has not needed a exceeded a shading value > 16.

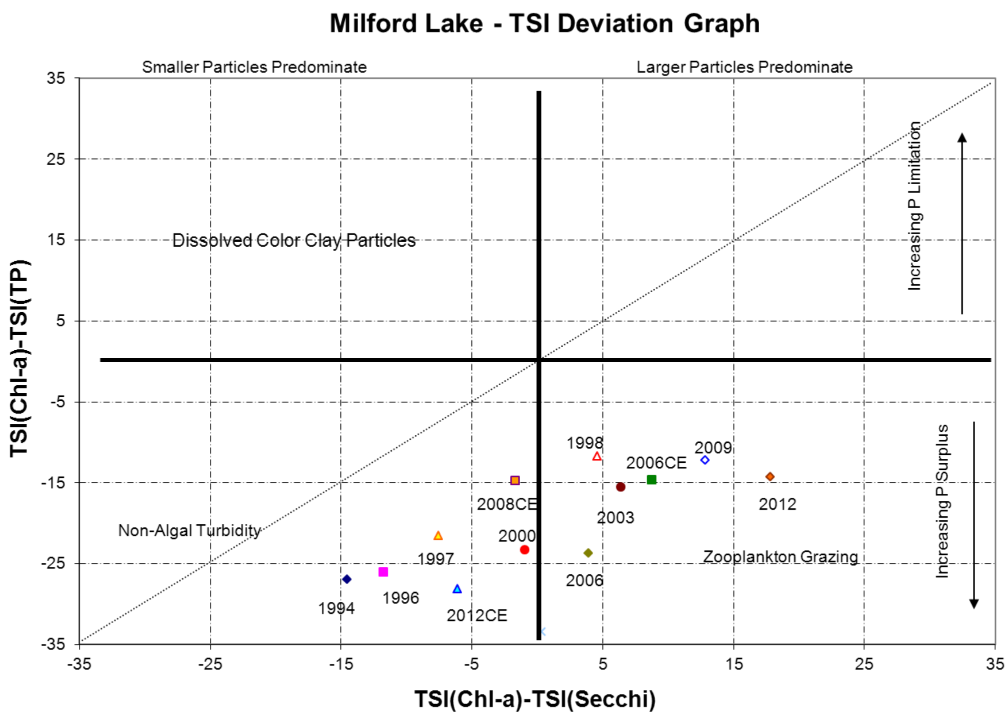
The above metrics conclude Milford Lake has generally low levels of suspended silt and/or clay and inorganic turbidity is not assuming a significant limiting role; there is a moderate to high response by algae to nutrient input; inorganic turbidity is not typically responsible for light extinction in the water column; there is a moderate amount of light available in the mixed zone and self shading of algae does not impede productivity.

Table 4. Milford Lake limiting factor metrics.

Year	Source	Non-Algal Turbidity	Light Availability in the Mixed Layer	Partioning of Light Extinction between Algae & Non-Algal Turbidity	Algal Use of Phosphorus Supply	Light Availability in the Mixed Layer for a Given Surface Light	Shading in Water Column due to Algae and Inorganic Turbidity	Chl-a (ug/L)
		NAT	**Zmix*NAT**	**Chl-*a**SD**	**Chl-a/TP**	**Zmix/SD**	**Shading**	
1991	KDHE	0.21	1.23	23.85		3.05		12.55
1994	KDHE	0.69	4.01	4.03	0.04	4.46		3.1
1996	KDHE	0.85	4.92	6.05	0.05	5.80		6.05
1997	KDHE	0.71	4.11	8.86	0.07	5.27		8.05
1998	KDHE	0.22	1.28	24.88	0.17	3.39	9.65	14.55
2000	KDHE	0.39	2.24	14.36	0.06	3.49	9.02	8.65
2003	KDHE	0.15	0.87	28.86	0.13	3.14	9.63	15.6
2006	KDHE	0.21	1.21	19.72	0.06	2.40	8.79	8.15
2006	USACE	<0.001	<0.001	41.04	0.17	4.00		28.3
2008	USACE	0.51	2.97	15.60	0.13	4.86		13.08
2009	KDHE	<0.001	<0.001	62.05	0.23	3.97	14.03	42.5
2011	USACE	0.68	3.93	10.29	0.05	5.30		9.4
2012	KDHE	<0.001	<0.001	101.81	0.23	3.87		67.88
2012	USACE	0.34	1.95	15.70	0.03	3.21		8.68

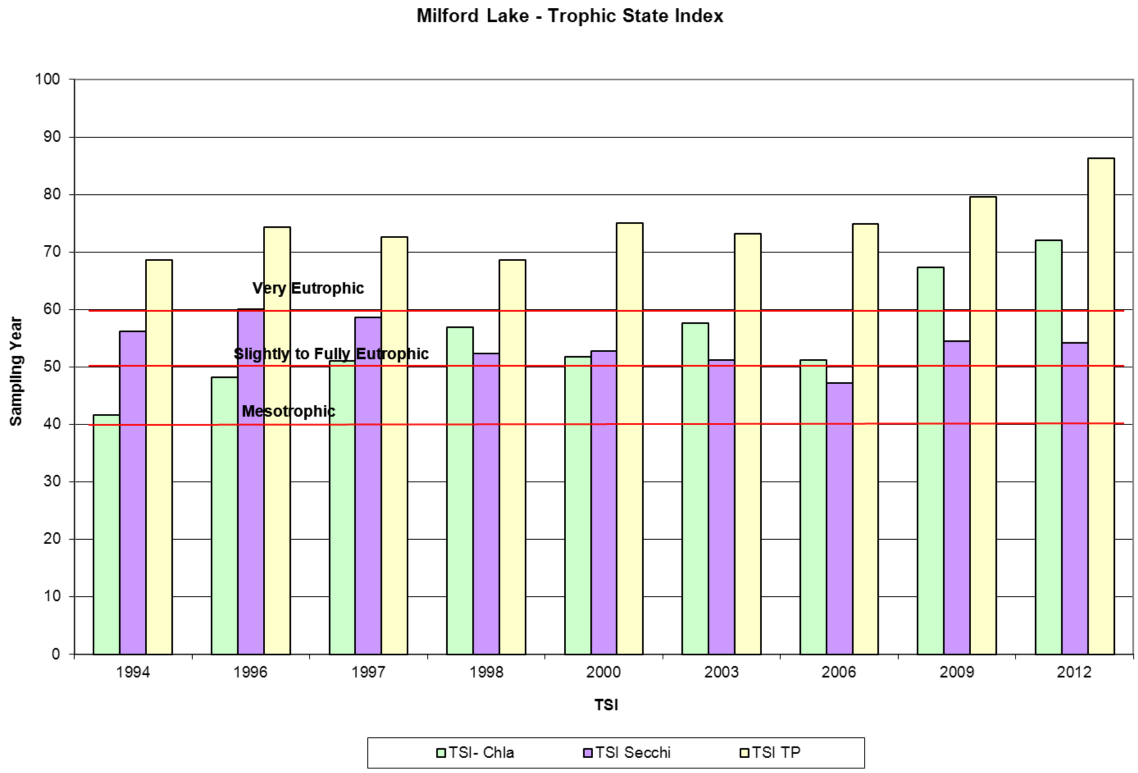
Another method for evaluating limiting factors is the TSI deviation metrics. Figure 6 (Multivariate Deviation Graph) summarizes the current trophic conditions at Milford Lake using a multivariate TSI comparison chart for data obtained by KDHE throughout the period of record. Where TSI (chl-a) is greater than TSI (TP), the situation indicates phosphorus is limiting chlorophyll *a*, whereas negative values indicate turbidity limits chlorophyll *a*. Where TSI(Chl-a)-TSI(SD) is plotted on the horizontal axis, if the Secchi depth (SD) trophic index is less than the chlorophyll *a* trophic index, than there is dominant zooplankton grazing. Transparency would be dominated by non-algal factors such as color or inorganic turbidity if the Secchi depth index were more than the chlorophyll *a* index. Points near the diagonal line occur in turbid situations where phosphorus is bound to clay particles and therefore turbidity values are closely associated with phosphorus concentrations. For the years plotted in Figure 6 Milford Lake varies between dominant zooplankton grazing and non-algal factors. For the years where chlorophyll *a* concentrations are greater than 10 ug/L, the lake is typically dominated by zooplankton grazing and phosphorus limitations on chlorophyll *a* are increased more so than the other sampling years.

Figure 6. Multivariate TSI comparison chart for Milford Lake.



The Carlson Trophic State Index (TSI) for Chlorophyll *a* shows an increasing trend from mesotrophic in 1994 to very eutrophic in 2012. The TSI for secchi depth is consistently between slightly to fully eutrophic, whereas the TSI for total phosphorus is consistently very eutrophic in Milford Lake (Figure 7).

Figure 7. Milford Lake Trophic State Indices.



The median trophic conditions within Milford Lake compared to other Federal lakes in the state are summarized in Table 5. The trophic indicator values within Milford Lake only meets the statewide benchmark for secchi depth. The median nutrient and chlorophyll *a* concentrations are higher than all the benchmarks.

Table 5. Median trophic indicator values of Milford Lake in comparison with other federal lakes and draft nutrient benchmarks in Kansas. Median values based on data from KDHE and USACE from 1996-2012. The nutrient benchmarks were derived from 47-58 lakes and reservoirs, based on the data collected between 1985-2002 (Dodds et al., 2006).

Trophic Indicator	Milford Lake	Federal Lake	Central Great Plains	Statewide Benchmark
Secchi Depth (cm)	148	95	117	129
TN (µg/l)	1090	903	695	625
TP (µg/l)	180	76	44	23
Chlorophyll *a* (µg/l)	13.08	12	11	8

The USACE sampled Milford Lake at numerous locations since 1996. Chlorophyll *a* concentrations were analyzed at the main basin (near the dam), middle lake, and upper lake. Table 6 summarizes the concentrations observed at the three sampling sites within the lake for the samples obtained by the USACE. The data indicate the upper portion of the lake takes the brunt of the nutrient and sediment loads arriving from the watershed. Conditions improve in the lake as it approached the main body of water near the dam.

Table 6. USACE annual average data summary for samples collected within Milford Lake (1996-2012).

USACE Sampling Point	Chl-a (µg/l) (2004-2012)	TN (mg/L)	TP (mg/L)	TN:TP Ratio	Secchi Depth (m)
Upper Lake	53.21	2.03	0.38	5.71	0.32
Middle Lake	26.61	1.15	0.24	5.63	0.75
Main Basin (near dam)	16.29	1.01	0.20	6.39	1.32

Algal Communities: As seen in Table 7, algal communities in Milford Lake have typically been dominated by blue-green algae, or cyanobacteria. The number of algal communities has sharply increased since 2009. An increasing supply of nutrients, especially phosphorus and possibly nitrogen, will often result in higher growth of blue-green algae because they possess certain adaptations that enable them to out compete true algae (Soil and Water Conservation Society of Metro Halifax, 2007). Several of the cyanobacteria species possess gas vacuoles that allow them to move within the water column vertically. This selective advantage allows for some species to move within the water column to avoid predation and reach optimal primary productivity. Their movement within the water column may influence chlorophyll *a* levels within the lake at various depths during the diel cycle.

Table 7. Algal Communities observed in Milford Lake during KDHE sampling years.

Sampling Date	TSI Chl-a	Total Count (cells/ml)	Percent Composition			
			Green	Blue Green	Diatom	Other
1991	55	12400	18	74	8	<1
1994	41.6	1450	65	0	0	35
1996	48.2	2898	15	76	7	2
1997	51.1	7277	10	82	8	<1
1998	56.8	9041	34	50	3	13
2000	51.7	4914	35	59	5	1
2003	57.5	24224	16	83	<1	<1
2006	51.2	23342	<1	99	<1	0
2009	67.4	151893	3	96	1	0
2012	72.0	233730	1	92	0	6

Relationships: Within Milford Lake there are positive relationships between; chlorophyll *a* and TSS; chlorophyll *a* and Turbidity; chlorophyll *a* and TN; chlorophyll *a* and TP; TP and TN; Turbidity and TN; and Turbidity and TP. There is a negative relationship between chlorophyll *a* and the TN:TP ratio; secchi depth and TN; TSS and the TN:TP ratio; and Turbidity and the TN:TP ratio. There are poor relationships between chlorophyll *a* and secchi depth; TSS and Turbidity; TSS and TP; TSS and TN; secchi depth and turbidity; and secchi depth and TSS. The various relationships are detailed in Figures 8-12.

Figure 8. Relationship between chlorophyll *a* and various parameters in Milford Lake.

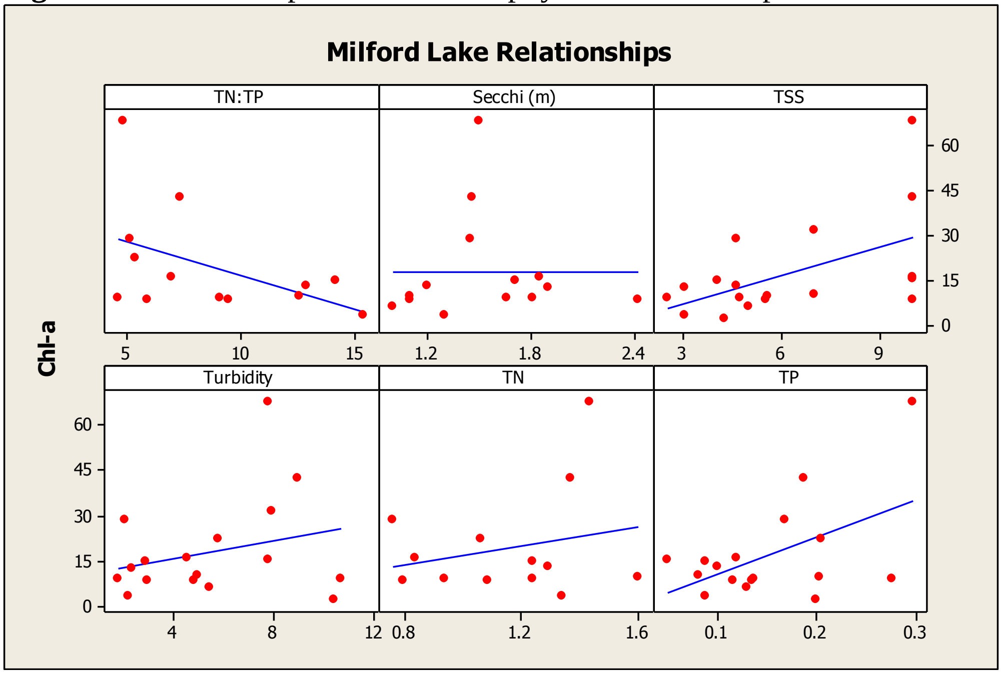


Figure 9. Relationships between secchi depth and various parameters in Milford Lake.

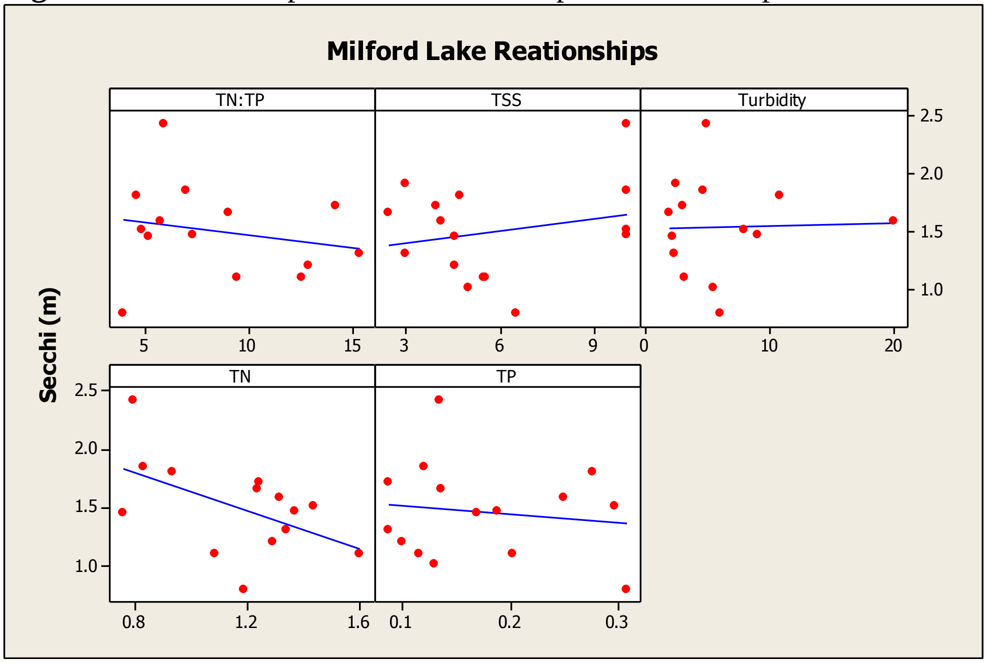


Figure 10. Relationship between TSS and various parameters in Milford Lake.

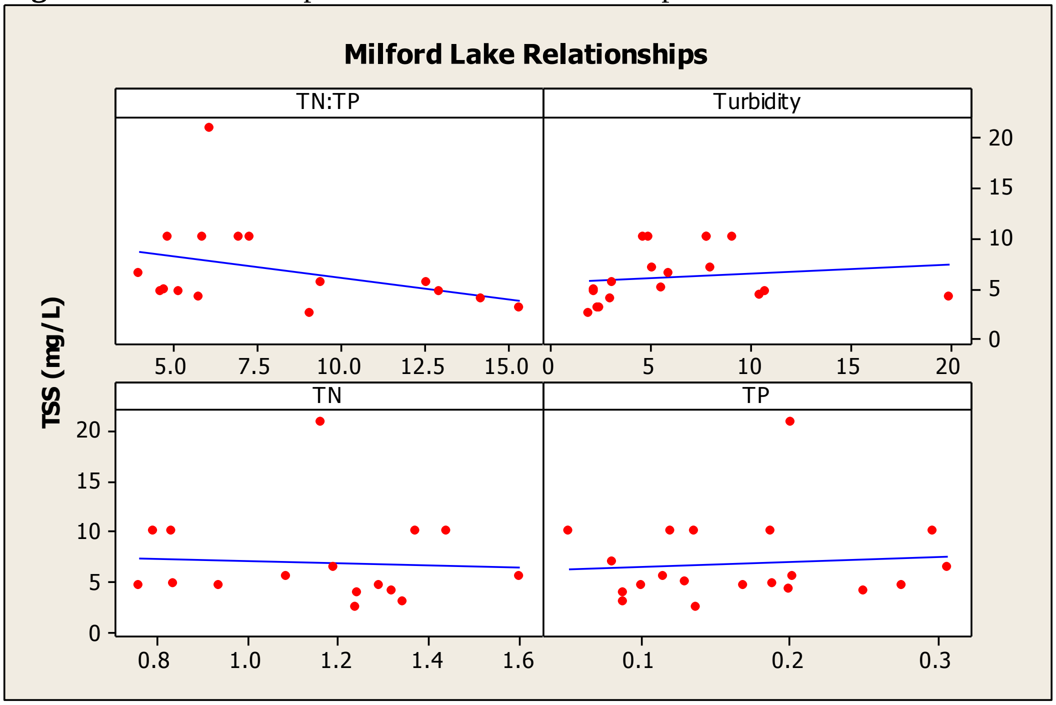


Figure 11. Relationship between Turbidity and various parameters in Milford Lake.

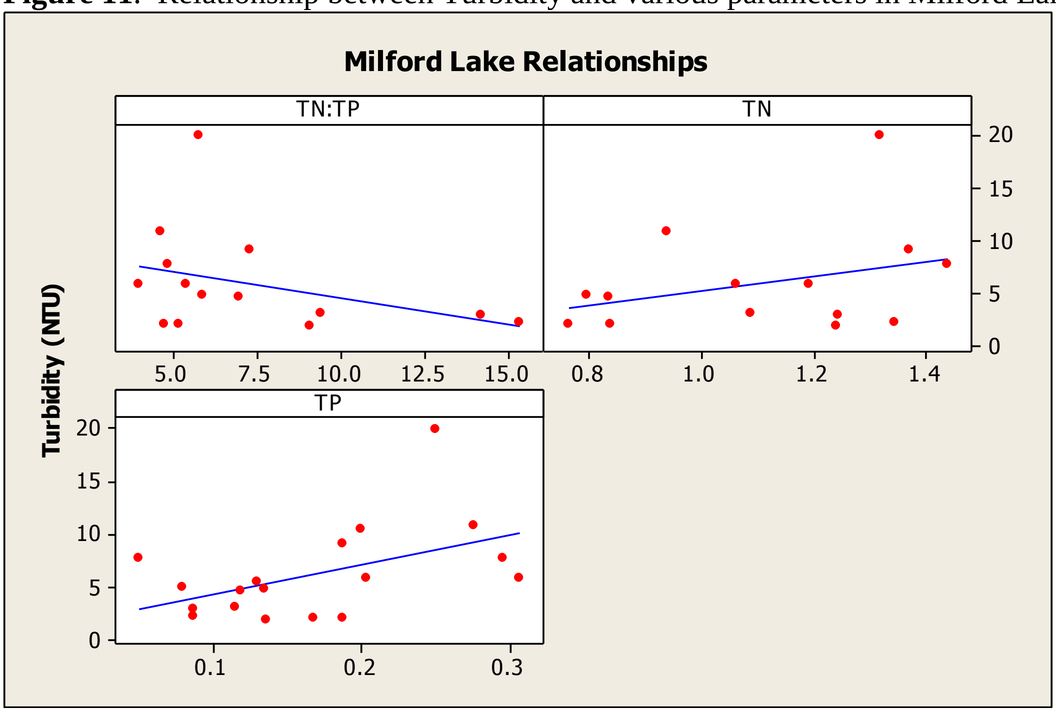
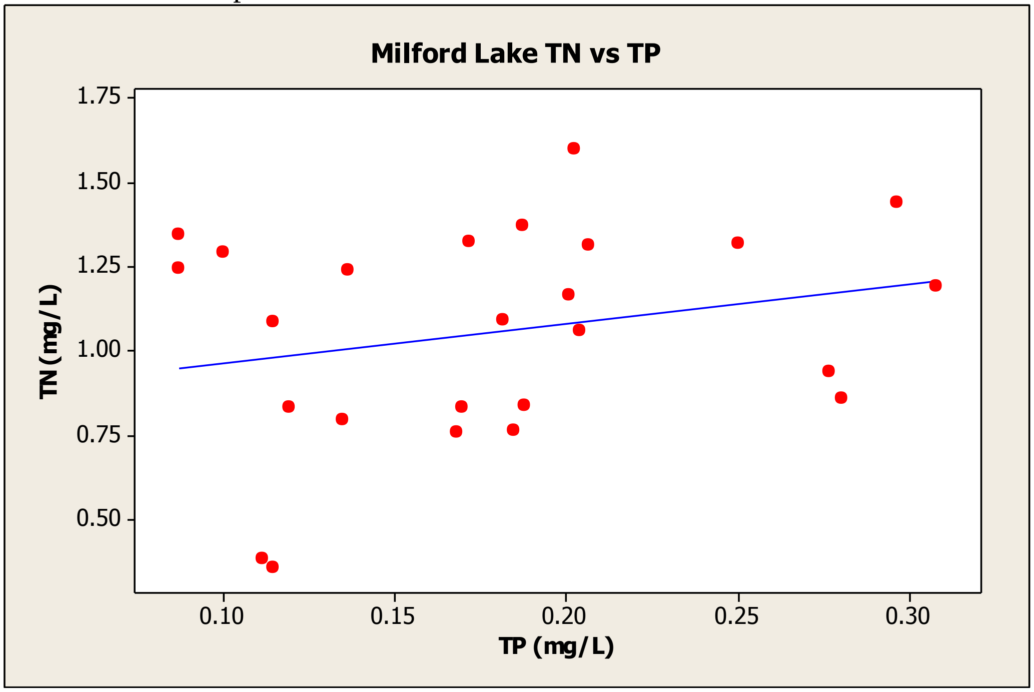


Figure 12. Relationship between nutrients in Milford Lake.



Stream Data: There are eleven KDHE stream monitoring stations within the Milford Lake watershed, of which all but SC711 is listed as impaired on the 303(d) list for Total Phosphorus. A summary stream data in the watershed is detailed in Table 8. Figures 13 and 14 detail a comparison between the TP and TN concentrations at the KDHE stream sampling stations within the watershed.

Table 8. KDHE stream station sampling average and median concentrations.

Station	TP Avg. (mg/L)	TP Median (mg/L)	TN Avg. (mg/L)	TN Median (mg/L)	TSS Avg. (mg/L)	TSS Median (mg/L)	# of Samples
SC231 – Republican R near Hardy	0.338	0.257	1.92	1.57	77.9	33.5	124
SC509 – Buffalo Cr near Concordia	0.470	0.407	2.70	2.35	139.4	81.0	124
SC707 – Wolf Cr near Concordia	0.499	0.370	1.60	1.54	108.6	37.0	25
SC510 Republican R. near Rice	0.357	0.287	1.84	1.85	111.1	48.0	124
SC650 - Salt Cr near Hollis	0.392	0.364	1.70	1.45	67.0	60.0	28
SC709 – Elm Cr near Ames	0.389	0.260	2.13	1.64	80.2	32.0	19
SC710 – Mulberry Cr near Clifton	0.320	0.210	1.63	1.09	119.9	27.0	23
SC649 – Peats Cr near Clifton	0.352	0.298	2.10	1.93	127.1	29.5	30
SC711 – Five Cr near Clay Center	0.171	0.167	0.88	0.75	26.0	16.0	25
SC504 – Republican R near Clay Center	0.442	0.318	1.82	1.70	173.4	83.5	38
SC503 Republican R	0.457	0.325	2.04	1.82	179.0	82.0	128

Figure 13. TP concentrations for KDHE sampling stations in the Milford Lake watershed.

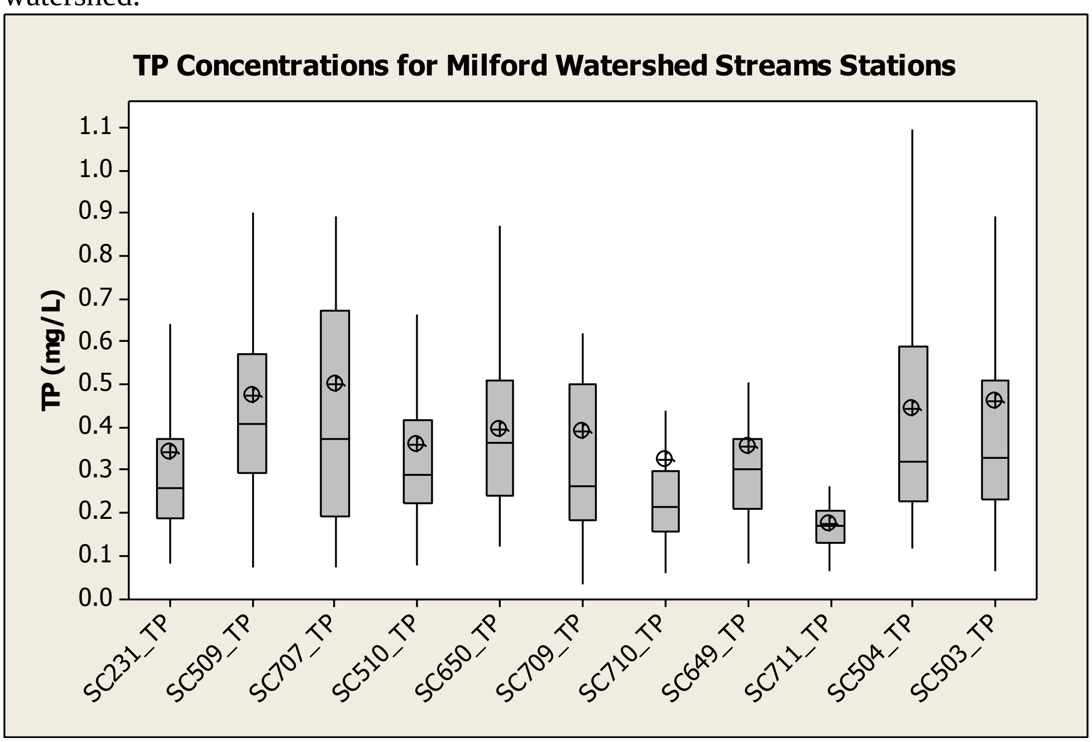


Figure 14. TN concentrations for KDHE sampling stations in the Milford Lake Watershed.

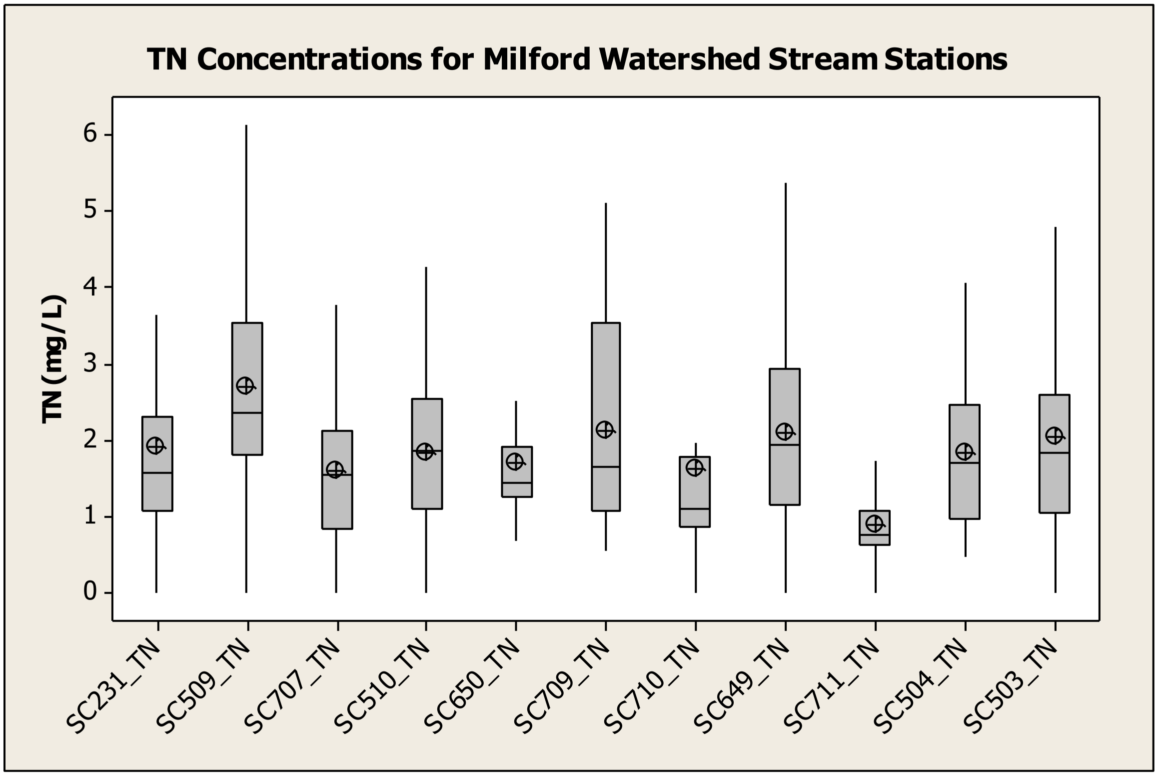
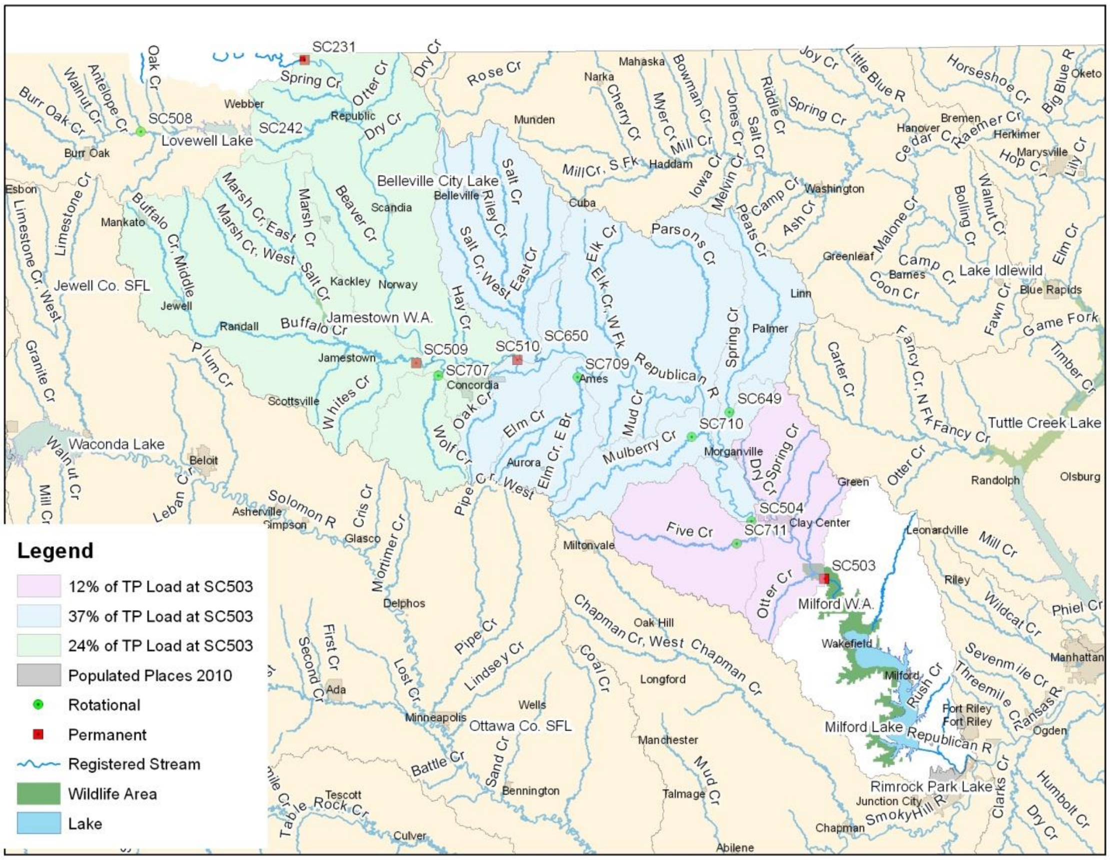


Table 9 details the current total phosphorus loads under average flow conditions by utilizing a mass balance calculation to estimate loads throughout the watershed. The average TP concentrations for each station were utilized for the mass balance calculation. The mass balance scenario provides a general estimate of the current loads in the watershed above KDHE sampling station SC503 (Republican River above Milford). The loads calculated between the various stations on the Republican River are based on the loads observed at the downstream Republican River stations and subtracting our the upstream loads that are accounted for at the upstream stations. The mass balance calculation suggests that 27% of the TP load reaching station SC503 is coming in from Nebraska above station SC231 (Republican River near Hardy); 24% of the TP load is attributed to the area in the watershed below the SC231 and above SC510 (Republican River near Rice); 37% of the TP load comes in below SC510 and above SC504 (Republican River near Clay Center); and 12% of the load reaching SC503 arrives below SC504 and above SC503. The contributing areas for the stations on the Republican River and the respective loads reaching the station above Milford Lake are detailed in Figure 15.

Table 9. Estimated Mass Balance of daily loads in the Milford watershed based on average flow values from Perry.

Stream	Drainage Area (square miles)	Average Flow (cfs)	Average TP (mg/L)	TP Load (lbs/day)	Percent of Load at SC503 on Republican River above Milford (%)
SC231 Republican River near Hardy	20593.98	332.61	0.338	607.08	27.10
SC509 Buffalo Cr	404.74	83.06	0.47	210.81	9.41
SC707 Wolf Creek	59.63	11.01	0.499	29.67	1.32
Republican R and other trib contribution between SC231 and SC510 on Republican R near Rice	715.51	161.31	0.328	285.97	12.77
SC650 Salt Creek	199.03	55.57	0.392	117.63	5.25
SC709 Elm Cr	77.02	21.42	0.389	44.99	2.01
SC710 Mulberry Cr	72.05	21.96	0.32	37.95	1.69
SC649 Peats Cr	104.16	33.08	0.352	62.88	2.81
Republican R and other trib contribution between SC510 and SC504 on Republican R near Clay Center	374.51	105.49	1.0	573.35	25.60
SC711 Five Cr	87.96	28.87	0.171	26.66	1.19
Republican R and other trib contribution between SC504 and SC503	213.79	53.28	0.844	242.94	10.85
SC503 Republican R above Milford	22902.38	907.66	0.457	2239.92	100.00

Figure 15. TP load contributions above Milford Lake based on the TP mass balance scenario.



Dissolved Oxygen: The temperature and dissolved oxygen profiles in Milford Lake are summarized in Table 10 for the period of record. During the sampling year of 2000, Milford Lake had dissolved oxygen deficiencies below 3 meters. This was the only sampling year that had DO concentrations less than 5 mg/L at the 0-3 meter depth range. Decomposition of plant material may lower the dissolved oxygen concentrations toward the lake bottom. The DO and temperature profile for the sampling year of 2000 and 2009 are detailed in Figure 16. There is not strong thermal stratification in the lake but DO dropped off suddenly in 2000 at approximately 7 m deep. Water temperature was high throughout the profile and not much primary productivity occurred in 2000 given the low DO levels and chlorophyll *a* level of 8.65 µg/L. Conversely, 2009 saw acceptable oxygen in the water column until below 14 meters. Temperature declined but remained above 20 degrees Celsius and chlorophyll *a* reached 42.5 µg/L in 2009, suggesting strong primary productivity took place within the lake. DO violations may be attributed to warm weather, which supported high microbial respiratory activities in either the water column or sediment. DO concentrations in Milford Lake decline at various rates depending on the sampling depth and year as seen in Figure 17.

Table 10. Shallow Dissolved Oxygen Sampled (mg/L by depth in Milford Lake.

Date / Depth	0 m	~0.5 m	~1 m	~2 m	~3 m	0-3 m Avg.	>3 m Avg.	Avg Temp
7/26/1976	14.2		13.6	12.8	9.1	12.4	3.9	26
5/7/1980	13.2	12.8	15	13.5	11.4	13.1	9.0	15.9
5/3/1982	9		8.9	9.1	9.1	9.0	9.0	12.1
6/8/1982	7		6.8	6.7	6.4	6.7	6.5	19.2
7/21/1982	6.4		6.2	6	5.8	6.1	4.75	25.3
8/31/1982	6.5		6.2	6.2	6.2	6.3	6.2	24.8
6/20/1988	7.4	7	7	7	6.8	7.0	5.8	22.1
6/24/1991	7.5	7.5	7.8	8	7.8	7.72	5.8	21.4
6/13/1994	6.4	6.4	6.4	6.5	6	6.3	3.4	20.6
8/26/1996	6.8	6.8	6.6	6.4	6.3	6.6	4.6	25.1
7/14/1997	7.4	7.4	7.5	6.2	6.1	6.9	3.7	23.4
7/6/1998	8.4	8.4	8.2	8.3	7.9	8.2	3.5	24.9
7/24/2000	5	5	5	5	4.8	4.96	1.5	25.2
7/21/2003	8.2	8.2	8.1	7.9	7.8	8.0	3.3	25.7
7/5/2006	7.4	7.3	7.3	7.3	7.2	7.3	4.95	23.4
6/23/2009	12.7	12.7	12.6	10.7	9.5	11.64	5.72	22.9

Figure 16. Milford Lake DO and Temperature profile during 2000 and 2009.

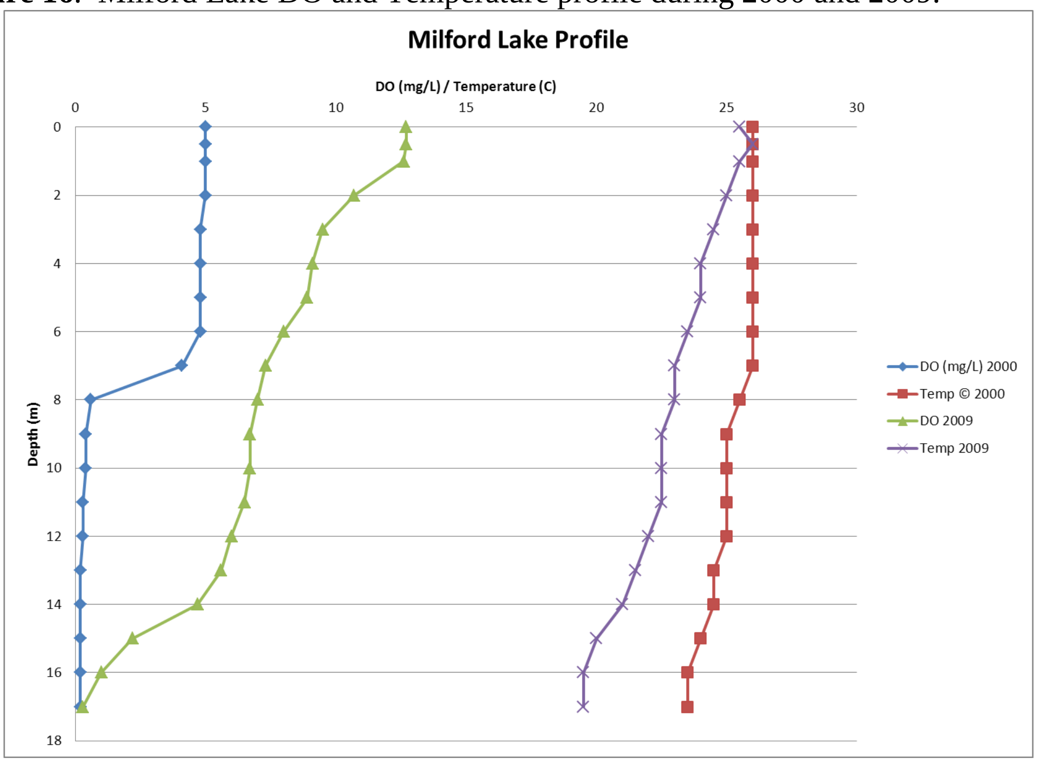
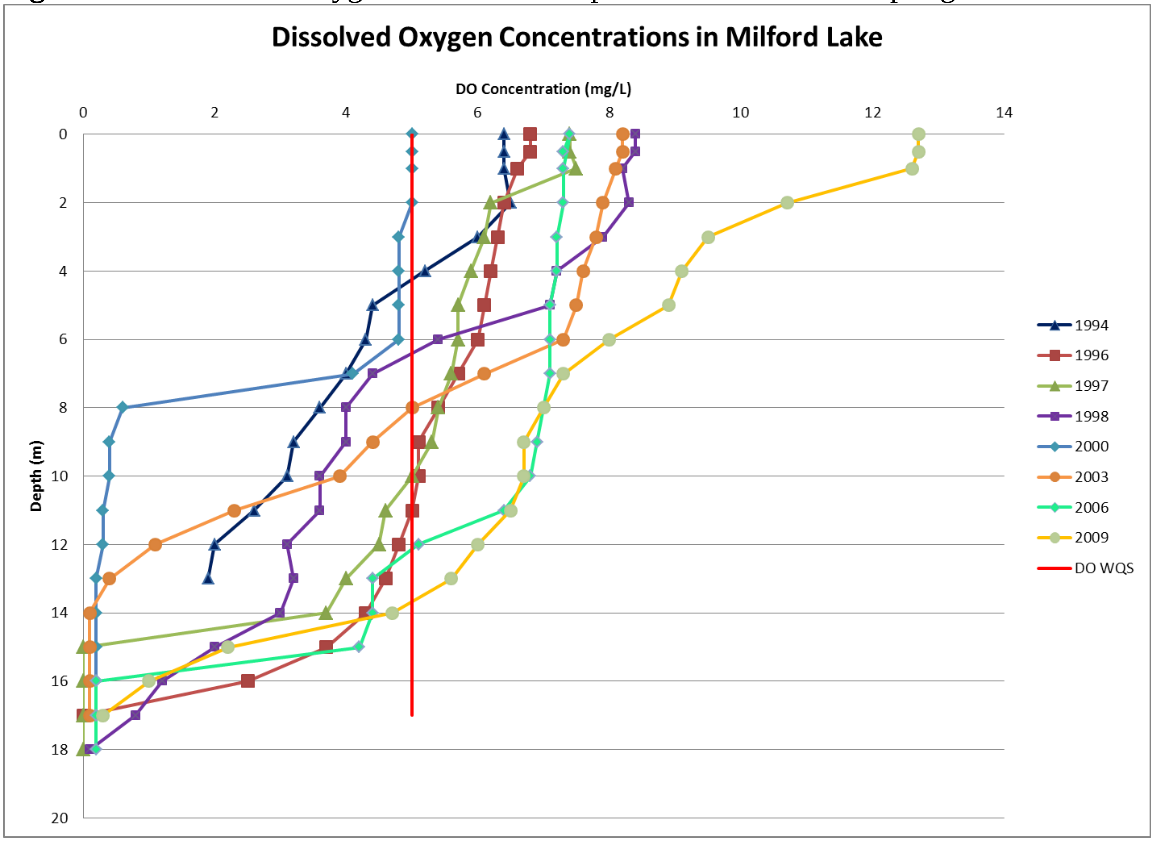


Figure 17. Dissolved Oxygen Concentration profiles for KDHE sampling events.



Storage Capacity: Based on the sedimentation rates established by the Kansas Water Office, Milford Lake is losing storage capacity at a slower rate than designed. The most recent lake survey was conducted in 2009, which has a calculated sedimentation rate of 1007 acre-ft/year. The design sedimentation rate for Milford lake is 1730 acre-feet/year.

Desired Endpoints of Water Quality (Implied Load Capacity) in Milford Lake:

In order to improve the trophic condition in Milford Lake from its recent Hypereutrophic status, the desired endpoint will be to maintain summer chlorophyll *a* average concentrations below 10 µg/L, with the reductions focused on nutrients (total N and P) entering the lake. The chlorophyll *a* endpoint of 10 µg/L is the statewide goal for Federal Lakes and lakes serving as Public Water Supplies, which will also ensure long-term protection to fully support Primary Contact Recreation and Aquatic Life within the lake. In order to improve the quality of the water column and the dissolved oxygen impairment, the endpoint should also result in the dissolved oxygen concentrations exceeding 5 mg/L for the entire water column of the lake.

Based on the BATHTUB reservoir eutrophicaton model (see Appendix A), total phosphorus and total nitrogen stream concentrations entering the lake must be reduced by 88%. With these reductions, the endpoint for Milford Lake will be met. These reductions at the inflows will result in a 71% reduction of TP, 75% reduction of TN, and a 68% reduction of Chlorophyll *a* within the lake. Achievement of the endpoints indicates loads are within the loading capacity of the lake, the water quality standards are attained, and full support of the designated uses of the lake have been achieved. Seasonal variation has been incorporated in this TMDL since the peaks of algal growth occur in the summer months. The current average condition for Milford Lake utilized in the model input was based on data from 2008-2012 from both the USACE and KDHE for the main basin of the lake and based on the USACE data obtained since 2008 for the upper segments in the model. The BATHTUB results for the current average lake condition and TMDL are detailed in Table 11. Stream chemistry and flow data for the Republican River from 2008-2012 was input into FLUX, which generated flow weighted concentration inputs for the Republican River inflows. The current lake average lake condition

Table 11. Milford Lake current average condition and TMDL based on BATHTUB

Lake Inflow	Current Average Condition	TMDL	Percent Reduction
TP – Annual Load (lbs/year)	1,216,912	148,341	88%
TP – Daily Load (lbs/day)	6335	772.19	88%
TP – Lake Concentration (µg/L)	287	83.3	71%
TN – Annual Load (lbs/year)	4,875,835	674,882	86%
TN – Daily Load (lbs/day)	20,706	2866	86%
TN – Lake Concentration (µg/L)	1722	427.8	75%

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are 44 NPDES permit facilities within the Milford Lake watershed (see Appendix D). Of these facilities, there are 17 that are non-discharging facilities and 26 permitted discharging facilities. Of the discharging facilities, there are 11 permitted municipal facilities and 15 industrial facilities. The discharging facilities in the Milford Lake watershed are detailed in Table 13.

Of the discharging facilities, there are currently nine permits that require nutrient monitoring. These facilities may be sources and contributors to the impairments associated within Milford Lake. These facilities along with their average discharge flow, average effluent TP concentration and their average effluent TN concentrations are listed in Table 12.

Table 12. Discharging Facilities with nutrient monitoring within the Milford Lake Watershed.

NPDES Facility	Average Discharge MGD	Nutrient Monitoring Frequency	Average TP (mg/L)	Avg. TN (mg/L)
NESIKA ENERGY, LLC - ETHANOL PLANT	0.045	Monthly	0.274	NA
BELLEVILLE, CITY OF	0.209	Monthly	2.8	7.51
CLAY CENTER, CITY OF	0.473	Monthly	3.16	13.49
CLIFTON, CITY OF	NA	Quarterly	2.47	NA
CLYDE, CITY OF	NA	Quarterly	2.97	NA
CONCORDIA, CITY OF	0.562	Monthly	3.55	18.08
COURTLAND, CITY OF	NA	Quarterly	2.51	NA
GEARY COUNTY SEWER DISTRICT #4	0.006	Monthly	2.17	15.87
VALLEY FERTILIZER	0.129	Monthly	NA	13.42

The non-overflowing permitted facilities are prohibited from discharging and may contribute a nutrient load under extreme precipitation or flooding events. Such events would not occur at a frequency or for duration sufficient to cause impairment in the watershed.

Table 13. NPDES Discharging Facilities in the Milford Lake Watershed.

Kansas Permit No.	Federal Permit No.	Facility	Type	Design Flow (MGD)	Permit Expires	Rec Stream
I-LR03-PR01	KSG110084	ABRAM READY MIX, INC.-BELLEVILLE PLANT	Concrete Basin	NA	9/30/2017	Riley Creek
I-LR05-CO02	KS0093459	CLAY CENTER POWER PLANT	Cooling Water	0.36	2/28/2017	Huntress Cr via Drainage Channel
I-LR05-PO01	KS0090018	VALLEY FERTILIZER	Remediation Project	0.129*	12/31/2014	Republican R vial Pipeline
I-LR05-PO02	KS0093351	CLAY CENTER GROUNDWATER REMED PWS 2	Remediation Project	0.432	2/28/2017	Republican R via Huntress Cr
I-LR05-PO04	KS0098477	CLAY CENTER WATER TREATMENT PLANT	Filters - RO Plant	0.69	12/31/2012	Republican R
I-LR05-PR01	KSG110172	MIDWEST PRODUCTS - CLAY CENTER PLANT	Washout pit	NA	9/30/2017	Republican R
I-LR05-PR02	KSG110216	MIDWEST PRODUCTS-CLAY CENTER (NEW)	Washout pit	NA	9/30/2017	Republican R
I-LR08-PO02	KS0002682	CLOUD CERAMICS - #C-77 & #C-80	Settling Pond	NA	12/31/2017	Republican R via Oak Creek
I-LR08-PR01	KSG110064	CONCORDIA READY-MIX	Washout pit	NA	9/30/2017	Republican R via Unnamed Trib
I-LR08-PR02	KSG110080	ABRAM READY MIX, INC. - CONCORDIA PLANT	Washout pit	NA	9/30/2017	Lost Cr
I-LR14-PR01	KSG110135	MIDWEST PRODUCTS - LINN PLANT	Earthen Basin	NA	9/30/2017	Peats Cr
I-LR15-PR02	KSG110170	PENNY'S CONCRETE - HWY 57 PLANT, J.C.	Concrete Basin	NA	9/30/2017	Republican R via Unnamed Trib
I-LR17-PO02	KS0090891	BAYER CONSTRUCTION (PS QRY)	Dewatering Pit	NA	4/30/2015	Milford L via Unnamed trib
I-LR22-PO01	KS0096539	NESIKA ENERGY, LLC - ETHANOL PLANT	Mechanical Plant	0.083	12/31/2016	Republican R
I-LR24-PO03	KS0098043	BAYER CONSTRUCTION - MARTIN QUARRY	Stormwater runoff	NA	12/31/2015	Mall Cr
M-LR03-OO01	KS0027529	BELLEVILLE, CITY OF	Mechanical Plant	0.4	6/30/2015	Salt Cr via Unnamed Trib
M-LR05-OO01	KS0048399	CLAY CENTER, CITY OF	Mechanical Plant	0.715	6/30/2015	Republican R
M-LR06-OO01	KS0048437	CLIFTON, CITY OF	3-cell Lagoon	0.121	6/30/2012	Republican R
M-LR07-OO01	KS0022403	CLYDE, CITY OF	3-cell Lagoon	0.0865	12/31/2015	Republican R
M-LR08-OO01	KS0025577	CONCORDIA, CITY OF	Mechanical Plant	1.35	6/30/2015	Republican R
M-LR09-OO01	KS0083399	COURTLAND, CITY OF	3-cell Lagoon	0.0525	3/31/2015	Beavery Cr via unnamed Trib
M-LR15-OO04	KS0079197	GEARY COUNTY SEWER DISTRICT #4	Mechanical Plant	0.016	6/30/2015	Milford Lake
M-LR16-OO02	KS0095231	MANKATO, CITY OF	3-cell Lagoon	0.136	3/31/2015	Middle Buffalo Cr
M-LR17-OO01	KS0086231	MILFORD, CITY OF	4-Cell Lagoon	0.058	3/31/2015	Republican R
M-LR18-OO01	KS0024678	MORGANVILLE, CITY OF	2-Cell Lagoon	0.02	6/30/2015	Dry Cr
M-LR24-OO01	KS0027545	WAKEFIELD MWTP	4-Cell Lagoon	0.141	9/30/2016	Milford Lake via unnamed trib

*Valley Fertilizer does not have a design flow but a pumping rate flow for their remediation recovery well.

Population Density: According to the 2010 census data from the U.S. Census Bureau, the population of the entire watershed is approximately 21,291 people, and therefore the population density for the watershed is approximately 9.73 people/square mile. There are numerous municipalities within the watershed that are detailed in Table 14 that account for 18,032 people within the watershed. The population trends for the majority of the cities within the watershed indicate stable or declining populations. The cities of Wakefield, Milford, and Palmer are the only three cities within the watershed that increased population between the 2000 and 2010 Census, with the City of Wakefield experiencing the highest growth rate.

Table 14. US Census Populations for municipalities within the Milford Lake Watershed.

COUNTY	CITYPROPER	2000 U.S. Census	2010 U.S. Census
Cloud	Concordia	5714	5395
Clay	Clay Center	4564	4334
Republic	Belleville	2239	1991
Clay	Wakefield	838	980
Jewell	Mankato	976	869
Cloud	Clyde	740	716
Washington	Clifton	557	554
Geary	Milford	502	530
Jewell	Jewell	483	432
Washington	Linn	425	410
Republic	Scandia	436	372
Cloud	Jamestown	399	286
Republic	Courtland	334	285
Clay	Morganville	198	192
Clay	Green	147	128
Republic	Republic	161	116
Washington	Palmer	108	111
Jewell	Formoso	129	93
Republic	Agenda	81	68
Jewell	Randall	90	65
Cloud	Aurora	79	60
Washington	Vining	58	45

Livestock Waste Management Systems: There are 184 certified or permitted confined animal feeding operations (CAFOs) within the Milford Lake watershed (see Appendix C). All of these livestock facilities have waste management systems designed to minimize runoff entering their operation and detain runoff emanating from their facilities. These facilities are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that is less than 1-5% of the time. Though the total potential number of animals is approximately 286,571 head in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number.

According to the Kansas Agricultural Statistics the estimated number of all cattle and cows and hogs for counties that are included within this watershed as of January 1, 2010 and 2011 are detailed in Table 15. The animal waste from both confined and unconfined feeding sites is considered a possible major source of nutrient loading into Milford Lake. Of particular concern are lands near the riparian areas that are subject to livestock grazing or watering and fertilizer applications.

Table 15.   Livestock Cattle and Calves in the counties within the Milford Lake Watershed.

County	Number of All Cattle and Calves as of Jan. 1, 2010	Number of All Cattle and Calves as of Jan. 1, 2011	Number of Hogs as of Jan 1, 2010	Number of Hogs as of Jan. 1, 2011
Cloud	35,000	32.500	2500	2700
Clay	35,000	31,000	29500	31000
Dickinson	49,000	72,000	10000	10600
Geary	15,000	11,900	Na	Na
Jewell	33,000	36,500	Na	Na
Riley	23,000	24,000	22000	23000
Republic	60,000	44,500	Na	Na
Washington	47,000	71,000	85000	90000

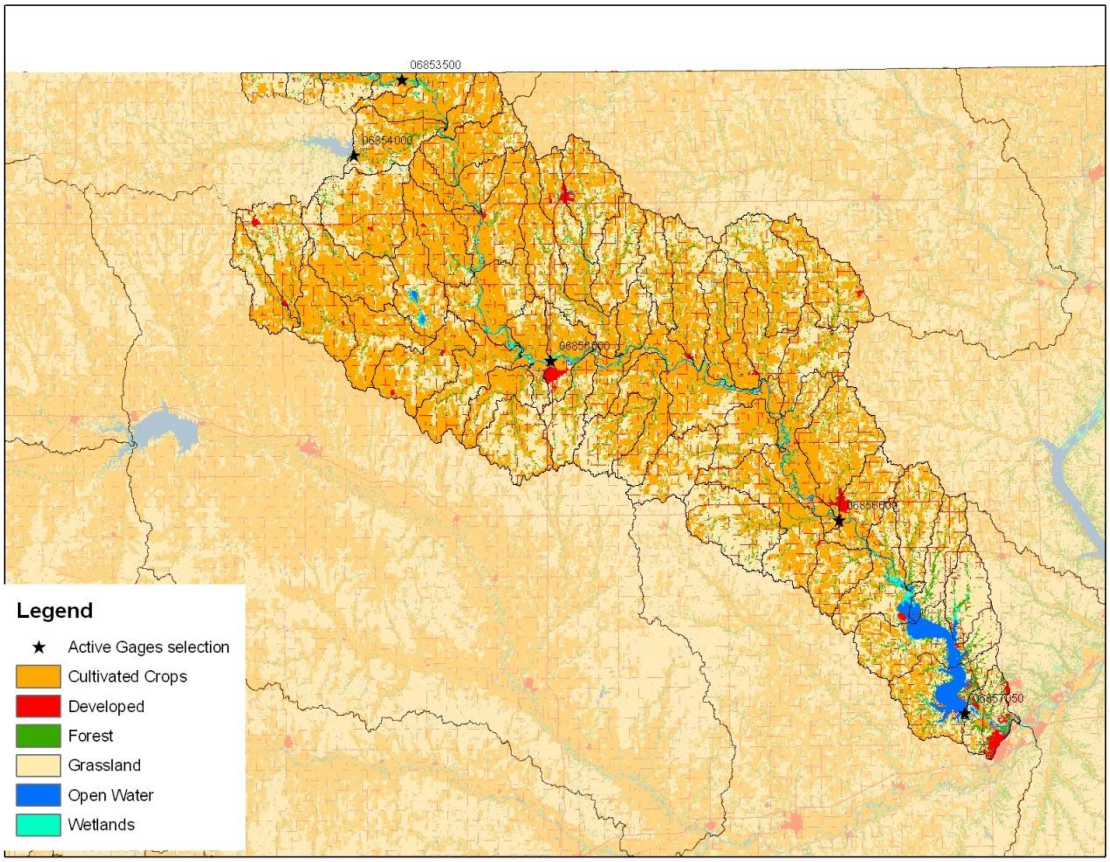
On-Site Waste Systems: Households outside of the municipalities that operate a wastewater treatment facility are presumably utilizing on-site septic systems.   There are approximately 18,032 people living within the municipalities served by wastewater treatment facilities within the watershed, and therefore there are approximately 3,259 people within the watershed utilizing on-site septic systems. Significant nutrient loading may occur if a system fails and it is located near a stream. However, based on the size of this watershed it is likely that on-site septic systems are an insignificant source contributing to the impairment within the Milford Lake watershed.

Landuse: The predominant land cover in the Milford Lake watershed includes 50.53% cropland, 37.05% grassland, 4.54% forest and 4.04% roadways. The remaining landuses summarized from the 2001 NLCD for the watershed are detailed in Table 16. As seen in Figure 18, the majority of the cropland lies within the flood plain of the Republican River and the tributary streams within the watershed.

Table 16. General Land Use acres in the Milford Lake Watershed.

Landuse	Acres	Percentage of Watershed
Cropland	763,486	50.53
Grassland	559,861	37.05
Forest	68,851	4.54
Roads	61,077	4.04
Open Water	27,622	1.83
Developed	16,278	1.08
Wetlands	13,769	0.91
Other	247	0.02

Figure 18. Milford Lake Watershed land use and land cover map (2001 NLCD).



Contributing Runoff: The watershed of Milford Lake has a mean soil permeability value of 1.16 inches/hour, ranging from 0.01 to 13.0 inches/hour according to the NRCS STATSGO database. About 65% of the watershed has a permeability value less than 1.14 inches/hour, which contributes to runoff during very low rainfall intensity events. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability. Over 95% of the watershed has a permeability value less than 1.29 inches/hour. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

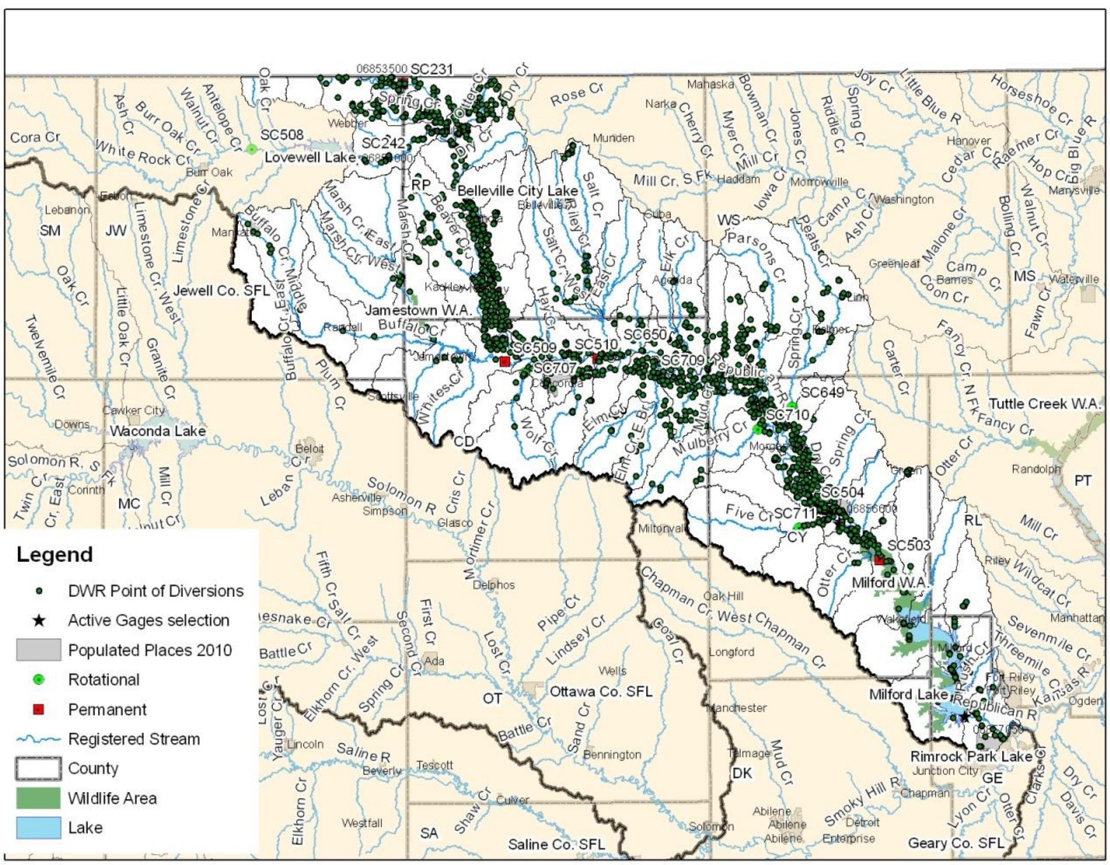
Water Diversions: There are 2,308 unique points of diversions within the five counties encompassing the watershed. The leading use of water in Riley County is for municipal use; whereas irrigation is the leading use for all other counties within the watershed. Geary and Jewell Counties have the fewest points of diversions and Clay, Cloud, Washington, and Republic all have the highest number of points of diversions as seen in

Table 17. As seen in Figure 19, the majority of the points of diversion all are in close proximity to the Republican River or it's tributaries.

Table 17. Points of Diversion

County	Points of Diversion	Authorized Surface Water (Acre-Feet)	Authorized Groundwater (Acre-Feet)	Total Authorized Acre-Feet	Acres Authorized for Surface Water Irrigation	Acres Authorized for Groundwater Irrigation
Clay	373	12081	27606	39687	5605	23089
Cloud	379	1845	31951	33796	1884	27877
Dickinson	261	24291	11393	35684	3743	7290
Geary	127	7074	15296	22370	1807	4294
Jewell	111	125163	4090	129253	2970	2831
Republic	488	9703	36942	46645	9738	29724
Riley	213	1490	18951	20441	1078	7716
Washington	356	5778	15603	21381	6774	12152

Figure 19. Points of Diversion in the Milford Creek Watershed.



Background: Phosphorus is naturally found in rocks, soil and organic material and is essential for the growth of aquatic and terrestrial vegetation, to include agricultural crops. The natural erosion of soil contributes to the amount of background phosphorus and nitrogen within the watershed that becomes available as nutrients to the ecosystem. However, erosion that may be facilitated by human activities and practices may cause excess runoff and streambank erosion, which contributes to high levels of suspended phosphorus-bound streambed sediment during runoff events. Land use changes such as the removal of riparian forests and wetlands, streambank erosion, urbanization, and agricultural activities, to include manure application to cropland, may significantly effect the levels of total phosphorus and nitrogen in aquatic systems. The typical levels of nutrients within some streams have been significantly increased due to human activities and land use changes and practices within Kansas, and therefore it is difficult to determine what the actual background phosphorus concentrations within the watershed are expected to be. The atmospheric deposition of nutrients may also contribute to the nutrient load within the watershed. Wildlife activities located near the stream corridors and the lake may contribute to the nutrient loading in the watershed

Internal Loading: Undissolved nutrients bound to suspended solids in the inflow to Milford Lake are potentially significant sources of nutrients that may reside in the sediment layer of the lake. These internal nutrient loads can be re-suspended and continue to add to the nutrients in Milford Lake. Internal loading is a complex function of hydrologic conditions, lake morphometry and lake sediment nutrient availability.

4. ALLOCATIONS OF POLLUTANT REDUCTION RESPONSIBILITY

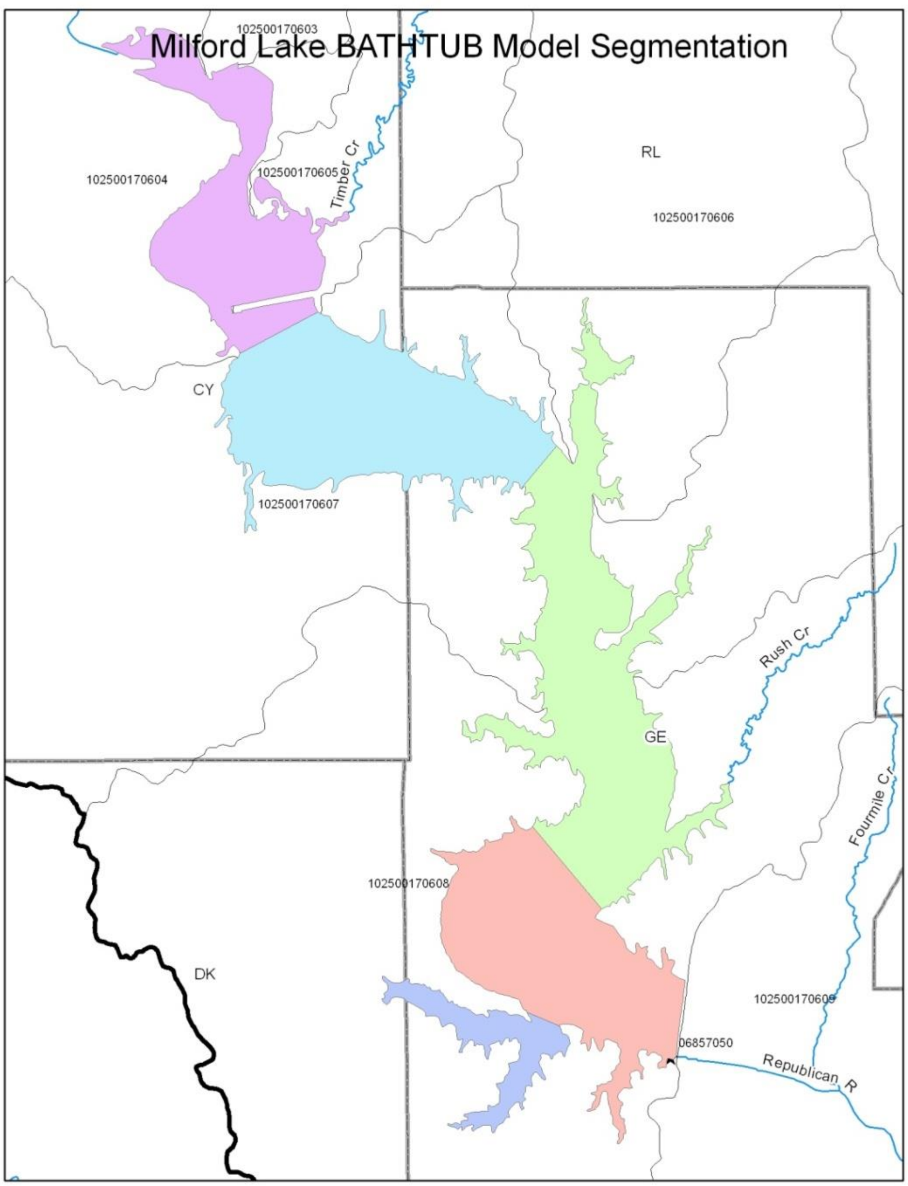
Milford Lake has varied between being co-limited by phosphorus and nitrogen and being limited by only nitrogen. Chlorophyll *a* concentrations within the main basin of the lake are greater than 10 ug/L during both conditions, and therefore both phosphorus and nitrogen allocations will be made under this TMDL.

BATHTUB is an empirical receiving water quality model that was developed by the U.S. Army Corps of Engineers (Walker, 1996), and has been widely used in the nation to address many TMDLs relating to issues associated with morphometrically complex lakes and reservoirs (Wang et al., 2005). The BATHTUB model was utilized for the eutrophication assessment of Milford Lake. Milford Lake was segmented into five sections for the BATHTUB model as seen in Figure 20, which included the riverine, upper pool (transitional area), middle pool (transitional area), main basin, and a cove area near the main basin. Atmospheric total nitrogen was obtained from the Clean Air Status and Trends Network (CASTNET), which is available at www.epa.gov/castnet/ . The CASTNET station from the Konza Prairie (KS) was utilized to estimate the atmospheric TN concentration for the model. Total Phosphorus atmospheric loading was estimated using the 1983 study of Rast and Lee. Water quality data from the main basin segment was averaged using the 2008-2012 data from KDHE and the USACE. Data associated with riverine and mid-pool were collected by the USACE from 2008-2012. Model input data for the lake inflow from the Republican River were estimated from FLUX, utilizing

KDHE monitoring data from station SC503 on the Republican River and USGS flow data from gage 06856600 on the Republican River near Clay Center. Inflowing concentrations from unmonitored tributaries flowing into the lake were estimated utilizing data from SC711 on Five Creek near Clay Center and flows were derived from USGS estimates (Perry, 2004).

The BATHTUB model was calibrated for the area-weighted mean per EPA's guidance. The model results (see Appendix A) estimate that the lake currently retains 75% of the TP and 52% of the TN load annually. Based on the modeling results, an 88% reduction of the TP and TN concentrations within the stream inflows of the lake are necessary to meet the TMDL endpoint.

Figure 20. BATHTUB Model Segmentation Map.



Point Sources: Wasteload Allocations are established for the discharging wastewater treatment facilities permitted within the watershed. There are 13 NPDES facilities that have been assigned a wasteload allocation, of which two are industrial facilities and eleven are municipal facilities. Of these, the largest wasteload allocations are associated with the cities of Concordia, Clay Center, and Belleville. Wasteload allocations for mechanical plants have been assigned based on an annual average discharge concentration of 1.5 mg/L TP and 8 mg/L TN at their respective design flows. The facilities that have not monitored nutients utilize lagoon systems, and have been assigned an annual average discharge concentration of 2.0 mg/L of TP and 8.0 mg/L of TN, which are concentrations typically observed in the effluent of lagoon systems in Kansas. The Nesika Energy facility discharges low concentrations of TP, and their WLA has been based on a TP concentration of 0.5 mg/L. The Valley Fertilizer industrial facility has been assigned an NO3 wasteload allocation based on the domestic waters supply use water quality standard of 10 mg/L. The wasteload allocations for Milford Lake are 41.7 lbs/day of TP and 223.1 lbs/day of TN. The discharging facilities with an assigned WLA are detailed in Table 18. All other permitted facilities in the watershed are not contributing to the impairment within the Milford Lake watershed and have been assigned a WLA of 0 lbs/day (Appendix D).

Table 18. Milford Lake Watershed Wasteload Allocations.

PERM_NO	FAC_NAME	Type	TP WLA Conc (mg/L)	TP WLA (lbs/day)	TN WLA Conc (mg/L)	TN WLA (lbs/day)
M-LR06-OO01	CLIFTON, CITY OF	Lagoon	2	2.0	8	8.1
M-LR07-OO01	CLYDE, CITY OF	Lagoon	2	1.4	8	5.8
M-LR09-OO01	COURTLAND, CITY OF	Lagoon	2	0.9	8	3.5
M-LR16-OO02	MANKATO, CITY OF	Lagoon	2	2.3	8	9.1
M-LR17-OO01	MILFORD, CITY OF	Lagoon	2	1.0	8	3.9
M-LR18-OO01	MORGANVILLE, CITY OF	Lagoon	2	0.3	8	1.3
M-LR24-OO01	WAKEFIELD MWTP	Lagoon	2	2.4	8	9.4
I-LR22-PO01	NESIKA ENERGY, LLC - ETHANOL PLANT	Mech	0.5	0.3	8	5.5
M-LR03-OO01	BELLEVILLE, CITY OF	Mech	1.5	5.0	8	26.7
M-LR05-OO01	CLAY CENTER, CITY OF	Mech	1.5	9.0	8	47.8
M-LR08-OO01	CONCORDIA, CITY OF	Mech	1.5	16.9	8	90.2
M-LR15-OO04	GEARY COUNTY SEWER DISTRICT #4	Mech	1.5	0.2	8	1.1
I-LR05-PO01	VALLEY FERTILIZER	Remediation	NA	0.0	10	10.8
	TOTAL WLA			41.7		223.1

Nonpoint Sources: Nonpoint sources are the main contributor for the nutrient input and impairment in Milford Lake. Background levels may be attributed to nutrient recycling and leaf litter. The assessment suggest that runoff transporting nutrient loads associated with animal wastes and cultivated crops where fertilizer has been applied, to include pasture and hay, contribute to the eutrophic condition of the lake. Nutrient load allocations for Milford Lake were calculated using the BATHTUB model (see Appendix A). A summary of the Milford Lake TMDL and the respective allocations are listed in Table 19.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus and nitrogen loads along with the chlorophyll *a* endpoint. Therefore, the margin of safety is explicitly set at 10% of the total allocations for the total phosphorus and nitrogen, which compensates for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality. The margin of safety for total phosphorus and nitrogen is 77.22 lbs/day and 286.6 lbs/day respectively, as indicated in Table 19.

Table 19. Milford Lake TMDL

Description	Allocations (lbs/year)	Allocations (lbs/day)
Phosphorus Atmospheric Load Allocation	1388.9	7.23
Phosphorus Nonpoint Source Load Allocations	116,897.6	646.04
Phosphorus Wasteload Allocation	15,220.5	41.7
Phosphorus Margin of Safety	14,834.1	77.22
Phosphorus TMDL	148,341.2	772.19*
Nitrogen Atmospheric Load Allocation	96,807.1	411.1
Nitrogen Nonpoint Source Load Allocation	429,155.4	1945.1
Nitrogen Wasteload Allocation	81,431.5	223.1
Nitrogen Margin of Safety	67,488.2	286.6
Nitrogen TMDL	674,882.2	2865.9*

*- See Appendix B for daily load calculations

State Water Plan Implementation Priority: Since Milford Lake is a very important multi-purpose reservoir for the region and has an active WRAPS group to manage the watershed, this TMDL will be a High Priority for implementation.

Priority HUC 12s & STEPL: The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was utilized to identify priority HUC12s within the watershed. STEPL is a simple watershed model that provides both agricultural and urban annual average sediment and nutrient simulations as well as implementation evaluation of best management practices. Preliminary STEPL results for phosphorus and nitrogen are illustrated in Figures 21 and 22. Based on the results initial priorities should focus on the individual preliminary implementation priority rankings identified in Table 20, based on watersheds with high unit loading of phosphorus (>2.2lbs/acre/year) and nitrogen (>10 lbs/acre/year). HUC12 areas that are below these initial thresholds would be secondary priority for implementation.

Figure 21. Milford STEPL map detailing the modeled pounds per acre per year of phosphorus associated with each HUC12 within the watershed.

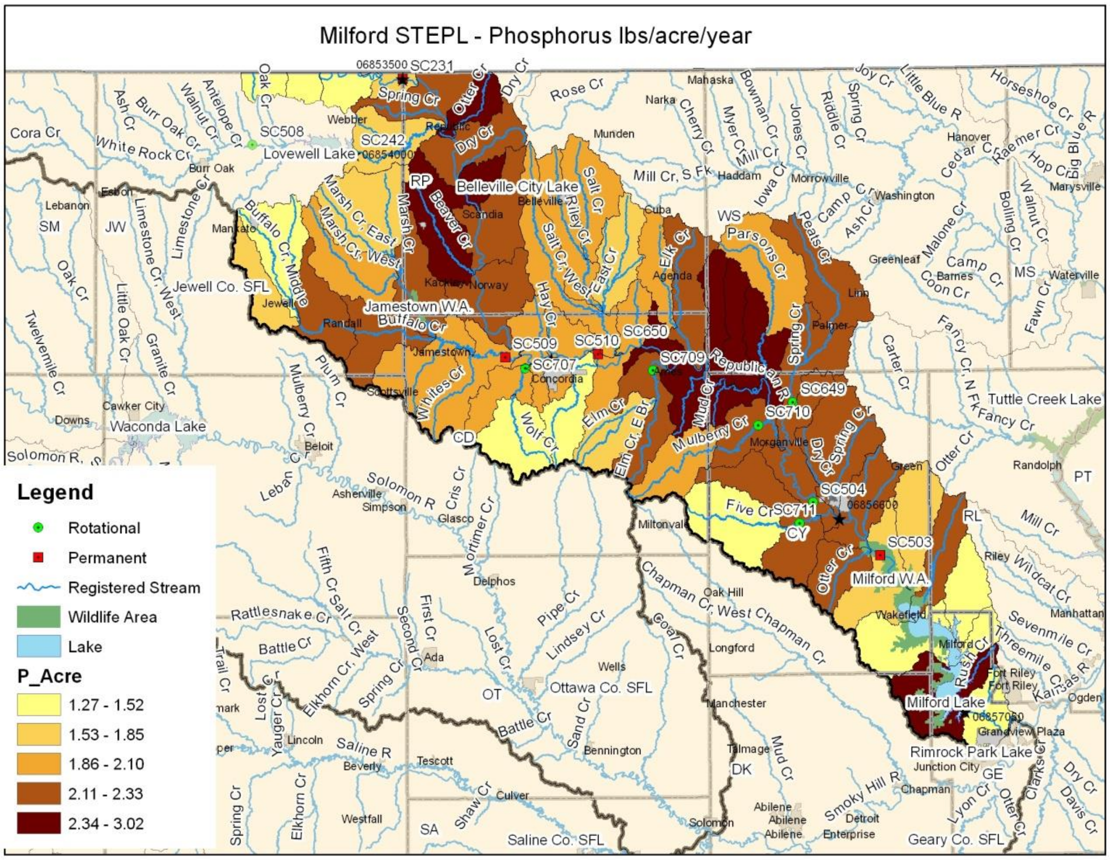


Figure 22. Milford STEPL map detailing the modeled pounds per acre per year of nitrogen associated with each HUC12 within the watershed.

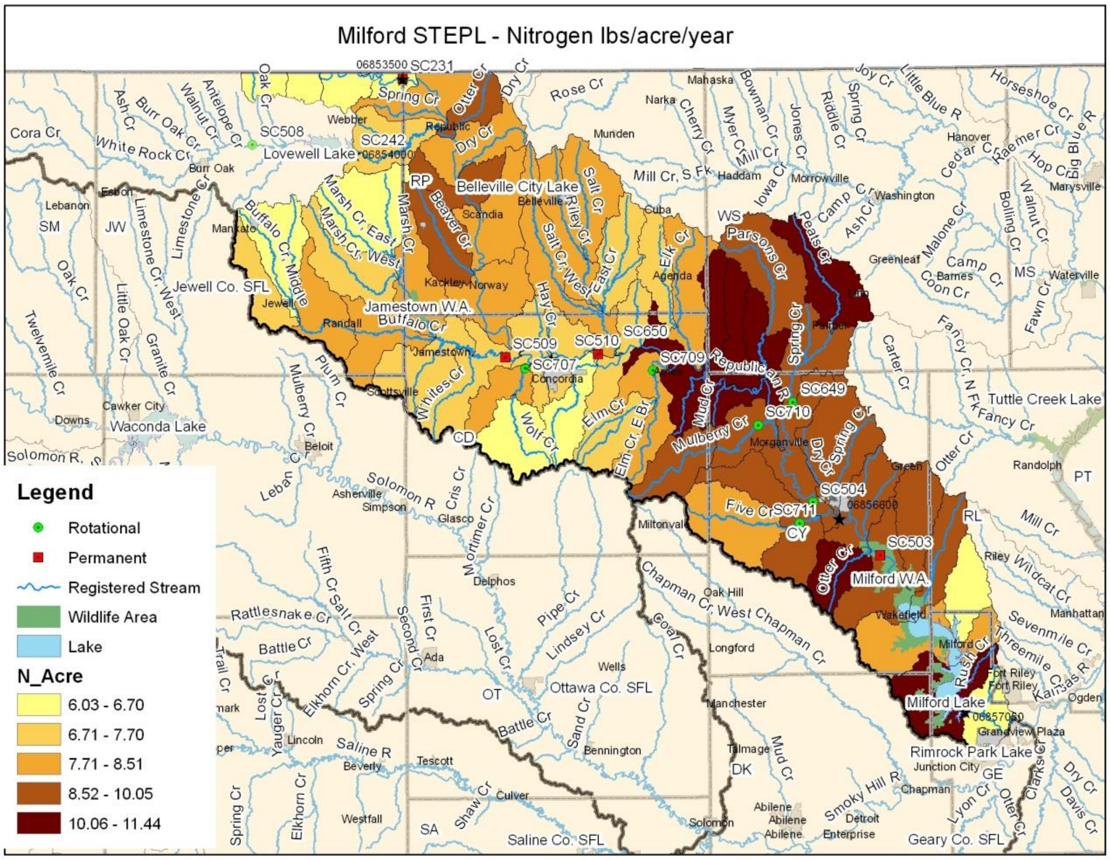


Table 20. Priority HUC 12 subwatersheds as identified through STEPL.

HUC12	HUC12 Name	TN Load (lbs/year)	TP Load (lbs/year)	TN per Acre (lbs/acre/year)	TP per Acre (lbs/acre/year)
102500170406	Scribner Creek	184523.76	48672.04	11.44	3.02
102500170608	Rush Creek-Milford Dam	305058.53	78924.22	11.28	2.92
102500170408	Outlet Parsons Creek	169876.30	43256.57	11.03	2.81
102500170405	Dry Creek	167394.10	41494.87	10.61	2.63
102500170409	Beaver Creek - Republican R	378648.26	94437.61	10.41	2.60
102500170601	Otter Creek	186887.49	41601.82	10.37	2.31
102500170501	Headwaters Peats Cr	295709.24	68047.66	10.14	2.33
102500170605	Timber Cr	189499.00	41408.67	10.05	2.20
102500170507	Spring Cr - Dry Cr	377503.31	86919.26	9.90	2.28
102500170508	Peat Cr - Republican R	248480.72	58828.17	9.80	2.32
102500170203	Courtland Canal - Beaver Cr	218238.73	63625.71	9.18	2.68
102500160901	Otter Cr - Republican R	113803.59	32754.68	9.05	2.60
102500160903	Mud Cr - Republican R	153817.56	44021.25	8.84	2.53
102500170402	Outlet Elm Cr	214094.52	57771.53	8.50	2.29
102500170204	Grave Cr- Republican R	226171.56	61891.92	8.23	2.25
102500170202	School Cr - Republican R	226058.06	61858.78	8.21	2.25
102500160902	City of Republic - Republican R	197179.81	54162.23	8.15	2.24
102500160805	Spring Cr - Republican r	248691.32	68677.68	8.12	2.24
102500170103	Spring Cr - Buffalo Cr	182982.14	50623.11	7.98	2.21

Unified Watershed Assessment Priority Rankings: The Milford Lake watershed lies within the Lower Republican Subbasin (HUC8: 10250017) with a priority ranking of 11 (High Priority for restoration work).

5. IMPLEMENTATION

Desired Implementation Activities: There is a very good potential that agricultural best management practices will improve the condition of Milford Lake. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cultivated croplands to ensure excess nutrients are not being applied.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Promote and adopt continuous no-till cultivation to increase the amount of water infiltration and minimize cropland soil erosion and nutrient transports.
4. Install grass buffer strips along streams and drainage channels in the watershed.
5. Reduce activities within riparian areas.
6. Implement nutrient management plans to manage manure land applications and runoff potential.
7. Adequately manage fertilizer utilization in the watershed and implement runoff control measures.

8. Install pasture management practices, including proper stock density to reduce soil erosion and storm runoff.
9. Renew state and federal permits and inspect permitted facilities for permit compliance.
10. Utilize state-supported Milford Lake WRAPS process to coordinate load reduction of nutrients to the lake.

Implementation Program Guidance:

NPDES-KDHE

a. Evaluate nutrient loading from all permitted dischargers in the watershed and establish applicable permit limits, as warranted.
b. Work with dischargers to reduce individual loadings of nutrients.
c. Inspect permitted livestock facilities to ensure compliance with minimal discharge.
d. New livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
e. New registered livestock facilities with less than 1000 animal units will apply pollution prevention technologies to secure their non-significant potential to pollute.
f. Manure management plans will be implemented, to include proper land application rates and practices that will prevent runoff of applied manure.

Watershed Management Program – KDHE

a. Support new and ongoing Section 319 implementation and demonstration activities conducted under the Milford Lake WRAPS project, including demonstration projects and outreach efforts dealing with nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management in the vicinity of streams.
d. Incorporate the provisions of this TMDL into WRAPS documents relating to Milford Lake.
e. Provide nutrient reduction as a co-benefit of ongoing WRAPS efforts to abate livestock loading of bacteria across the Milford Lake watershed

Water Resource Cost Share and Nonpoint Pollution Control Programs – KDA Division of Conservation

a. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.

b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.
c. Re-evaluate nonpoint source pollution control methods.

Riparian Protection Program- KDA Division of Conservation

a. Establish, protect or re-establish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects.
c. Promote wetland construction to assimilate nutrient loadings.

Buffer Initiative Program – KDA Division of Conservation

a. Install grass buffer strips near streams
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold nutrients.
f. Support outreach efforts by Milford Lake WRAPS projects and continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Time Frame for Implementation: Pollutant reduction strategies and pollutant source assessment should be initiated within the priority HUC12 subwatersheds in 2014 through the 9-element watershed plan of the WRAPS. Pollutant reduction practices and implementation activities within the priority HUC12 subwatersheds should be initiated by 2015 and continue through 2024.

Targeted Participants: The primary participants for implementation will be agricultural and livestock operations immediately adjacent to the streams within the priority subwatersheds. Conservation district personnel and county extension agents should conduct a detailed assessment of sources adjacent to streams within the watershed over 2014. The Milford Lake WRAPS will direct implementation activities that should target those areas with the greatest potential to influence nutrient concentrations within the Milford Lake watershed and should be targeted to:

1. Unbuffered cropland adjacent to the stream.
2. Sites where drainage runs through or adjacent to livestock areas.

3. Sites where livestock have full access to the stream and it is their primary water supply.
4. Conservation compliance on highly erodible areas.
5. Acreage of poor rangeland or overstocked pasture.
6. Poor riparian area and denuded riparian vegetation along the stream.
7. Fields with manure applications.

Milestone for 2019: In accordance with the TMDL vision strategy for Kansas, the year 2019 marks the next cycle of 303(d) activities in the Kansas Lower Republican Basin to review data in the Milford Lake watershed to assess improved conditions and develop necessary stream phosphorus TMDLs in the Republican and its tributaries. Should the impairment in the lake continue, adjustments to source assessment, allocation, and implementation activities may occur through the stream TMDLs

Delivery Agents: The primary delivery agents for program participation will be KDHE, the Division of Conservation, the Kansas State University Extension Service and the Milford Lake WRAPS teams. Implementation decisions and scheduling will be guided by planning documents prepared through Milford Lake WRAPS.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

5. K.S.A. 2-1915 empowers the Division of Conservation to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

6. K.S.A. 75-5657 empowers the Division of Conservation to provide financial assistance for local project work plans developed to control nonpoint source pollution.

7. K.S.A. 82a-901, et. seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

9. The *Kansas Water Plan* and the Kansas Lower Republican River Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

10. K.S.A. 32-807 authorized the Kansas Department of Wildlife and Parks to manage lake resources.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the Kansas Water Plan. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection through the WRAPS program. This watershed and its TMDL are a High Priority consideration for funding.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities. The key to success will be widespread utilization of conservation farming and proper livestock waste management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue to collect samples every 3 years from Milford Lake in order to assess the trophic state, with the next round of sampling to be conducted in 2015. Monitoring will also continue at the KDHE stream monitoring stations within the watershed to assess the nutrient load contributions from the respective monitoring stations. The Kansas City Corps of Engineers Office will continue to collect samples in Milford Lake on a monthly basis between April and October. Additionally, tracking the nutrient loads from point sources should be done to determine their contributions to the watershed and lake. The improved status of Milford Lake will be evaluated in 2019. If the impairment status continues, the desired endpoints under this TMDL will be further evaluated.

7. FEEDBACK

Public Notice: An active internet website was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Kansas Lower Republican Basin.

Public Hearing: A Public Hearing on the Kansas Lower Republican TMDLs was held on December 11, 2013 in Junction City to receive comments on this TMDL. A comment letter was received from the Friends of the Kaw regarding this TMDL.

Basin Advisory Committee: The Kansas Lower Republican Basin Advisory Committee met to discuss the TMDLs of the basin on March 17, 2011 in Manhattan, June 16, 2011 in Lawrence, September 29, 2011 in Topeka, and October 16, 2013 in Manhattan.

Milestone Evaluation: In 2019, evaluation will be made as to the degree of implementation which has occurred within the watershed. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2019 with consultation from local stakeholders and WRAPS teams.

Consideration for 303(d) Delisting: Milford Lake will be evaluated for delisting under section 303(d), based on the monitoring data over 2013-2021. Therefore, the decision for delisting will come about in the preparation of the 2024-303(d) list. Should modifications be made to the applicable water quality criteria during the implementation period consideration for delisting, desired endpoints of this TMDL and implementation activities might be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality, Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2015, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendations of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2014-2024.

Rev 5/27/2014

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Appendix A. BATHTUB Model Summary

Case Data for Current Conditions

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.81	0.0
Evaporation (m)	1.33	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	10	0.10
Total N	697	0.05
Ortho P	10	0.10
Inorganic N	697	0.05

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	2	2ND ORDER, DECAY
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	2	CONCENTRATIONS
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Riverine	2	1	10	2.5	8.3	2.5	0.12	0	0	1.05	0	0	0	0	0	0	0
2	Upper Pool	3	1	16	4.5	6.2	4.2	0.12	0	0	0.08	0	0	0	0	0	0	0
3	Mid Pool	4	1	20	8.6	17.7	6.3	0.12	0	0	0.84	0	0	0	0	0	0	0
4	Main Basin	0	1	14	12	7.3	7.2	0.12	0	0	0.08	0	0	0	0	0	0	0
5	Coves	4	1	3	8.6	6.1	6.1	0	0	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	450	0.3	2980	0.7	58	0.6	0.4	0.7	2440	0.7	250	0.3	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	260	0.3	1410	0.7	19.8	0.6	0.75	0.7	940	0.7	60	0.3	0	0	0	0
4	0	0	210	0.3	1270	0.2	28.3	0.9	1.44	0.2	860	0.2	50	0.3	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
4	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Republican R	1	1	22917	695	0.5	0	0	741	0.12	2920	0.16	296	0.5	1770	0.15
2	Timber Cr	2	1	153	20.72	0.5	0	0	350	0.5	1330	0.5	140	0.5	800	0.5
3	Rush Cr	3	1	28.13	4.51	0.5	0	0	350	0.5	1330	0.5	140	0.5	800	0.5
4	Milford Outflow	4	4	0	759	0.5	0	0	210	0	1260	0	10	0	430	0
5	Unnamed Tribs	3	1	331	77	0.5	0	0	350	0.5	1330	0.5	140	0.5	800	0.5
6	Wakefield MWTP	2	3	0	0.2	0	0	0	2000	0	8000	0	200	0	800	0
7	City of Milford	3	3	0	0.08	0	0	0	2000	0	8000	0	200	0	800	0
8	Geary Cnty Sewer	4	3	0	0.008	0	0	0	2170	0	15860	0	217	0	1586	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	2.164	0.45
Total Nitrogen	1.525	0.55
Chl-a Model	1.118	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Current Condition, Milford Lake BATHTUB predicted concentrations and observed concentrations.

Segment:	6	Area-Wtd Mean				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	293.0	0.51	97.8%	287.3	0.30	97.7%
TOTAL N MG/M3	1714.7	0.57	79.9%	1722.3	0.58	80.1%
C.NUTRIENT MG/M3	118.6	0.52	93.3%	118.9	0.50	93.4%
CHL-A MG/M3	34.5	0.34	95.4%	31.2	0.69	94.0%
SECCHI M	0.9	0.29	42.7%	0.9	0.44	40.0%
ORGANIC N MG/M3	978.6	0.30	92.2%	1255.5	0.59	97.2%
TP-ORTHO-P MG/M3	68.5	0.34	80.8%	100.0	0.30	89.7%
ANTILOG PC-1	1685.0	0.64	92.9%	1948.8	0.42	94.3%
ANTILOG PC-2	11.3	0.11	85.6%	10.7	0.38	83.5%
(N - 150) / P	5.7	0.80	5.4%	5.3	0.42	4.4%
INORGANIC N / P	3.4	1.42	1.5%	2.5	1.68	0.6%
TURBIDITY 1/M	0.5		38.9%	0.5		38.9%
ZMIX * TURBIDITY	2.3	0.09	34.9%	2.3	0.09	34.9%
ZMIX / SECCHI	6.4	0.23	69.4%	6.8	0.42	73.1%
CHL-A * SECCHI	27.4	0.13	91.9%	25.0	0.57	89.7%
CHL-A / TOTAL P	0.1	0.58	24.9%	0.1	0.47	17.0%
FREQ(CHL-a>10) %	88.3	0.09	95.4%	87.4	0.16	94.0%
FREQ(CHL-a>20) %	62.7	0.25	95.4%	56.9	0.43	94.0%
FREQ(CHL-a>30) %	42.6	0.38	95.4%	35.9	0.59	94.0%
FREQ(CHL-a>40) %	29.0	0.50	95.4%	23.5	0.70	94.0%
FREQ(CHL-a>50) %	20.0	0.62	95.4%	15.8	0.81	94.0%
FREQ(CHL-a>60) %	13.9	0.72	95.4%	11.0	0.94	94.0%
CARLSON TSI-P	84.5	0.09	97.8%	85.2	0.03	97.7%
CARLSON TSI-CHLA	64.3	0.05	95.4%	63.4	0.06	94.0%
CARLSON TSI-SEC	62.8	0.06	57.3%	63.2	0.08	60.0%

Current Condition, Milford Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Republican R	22917.0	695.0	1.21E+05	0.50	0.03
2	1	2	Timber Cr	153.0	20.7	1.07E+02	0.50	0.14
3	1	3	Rush Cr	28.1	4.5	5.09E+00	0.50	0.16
4	4	4	Milford Outflow		759.0	1.44E+05	0.50	
5	1	3	Unnamed Tribs	331.0	77.0	1.48E+03	0.50	0.23
6	3	2	Wakefield MWTP		0.2	0.00E+00	0.00	
7	3	3	City of Milford		0.1	0.00E+00	0.00	
8	3	4	Geary Cnty Sewer		0.0	0.00E+00	0.00	
PRECIPITATION				63.0	51.0	0.00E+00	0.00	0.81
TRIBUTARY INFLOW				23429.1	797.2	1.22E+05	0.44	0.03
POINT-SOURCE INFLOW					0.3	0.00E+00	0.00	
***TOTAL INFLOW				23492.1	848.5	1.22E+05	0.41	0.04
GAUGED OUTFLOW					759.0	1.44E+05	0.50	
ADVECTIVE OUTFLOW				23492.1	5.8	2.66E+05	9.99	0.00
***TOTAL OUTFLOW				23492.1	764.8	1.22E+05	0.46	0.03
***EVAPORATION					83.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Republican R	514995.0	93.3%	7.01E+10	99.4%	0.51	741.0	22.5
2	1	2	Timber Cr	7252.0	1.3%	2.63E+07	0.0%	0.71	350.0	47.4
3	1	3	Rush Cr	1578.5	0.3%	1.25E+06	0.0%	0.71	350.0	56.1
4	4	4	Milford Outflow	135501.0		1.07E+10		0.76	178.5	
5	1	3	Unnamed Tribs	26950.0	4.9%	3.63E+08	0.5%	0.71	350.0	81.4
6	3	2	Wakefield MWTP	400.0	0.1%	0.00E+00		0.00	2000.0	
7	3	3	City of Milford	160.0	0.0%	0.00E+00		0.00	2000.0	
8	3	4	Geary Cnty Sewer	17.4	0.0%	0.00E+00		0.00	2170.0	
PRECIPITATION				630.0	0.1%	3.97E+03	0.0%	0.10	12.3	10.0
TRIBUTARY INFLOW				550775.5	99.8%	7.05E+10	100.0%	0.48	690.9	23.5
POINT-SOURCE INFLOW				577.4	0.1%	0.00E+00		0.00	2004.7	
***TOTAL INFLOW				551982.9	100.0%	7.05E+10	100.0%	0.48	650.5	23.5
GAUGED OUTFLOW				135501.0	24.5%	1.07E+10		0.76	178.5	
ADVECTIVE OUTFLOW				1027.9	0.2%	8.57E+09		10.00	178.5	0.0
***TOTAL OUTFLOW				136529.0	24.7%	1.25E+10		0.82	178.5	5.8
***RETENTION				415453.9	75.3%	4.02E+10		0.48		

Overflow Rate (m/yr)	12.1	Nutrient Resid. Time (yrs)	0.2457
Hydraulic Resid. Time (yrs)	0.6052	Turnover Ratio	4.1
Reservoir Conc (mg/m3)	293	Retention Coef.	0.753

Overall Mass Balance Based Upon Component: **Predicted TOTAL N** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Republican R	2029400.0	91.8%	1.14E+12	99.5%	0.52	2920.0	88.6
2	1	2	Timber Cr	27557.6	1.2%	3.80E+08	0.0%	0.71	1330.0	180.1
3	1	3	Rush Cr	5998.3	0.3%	1.80E+07	0.0%	0.71	1330.0	213.2
4	4	4	Milford Outflow	1044892.5		6.36E+11		0.76	1376.7	
5	1	3	Unnamed Tribs	102410.0	4.6%	5.24E+09	0.5%	0.71	1330.0	309.4
6	3	2	Wakefield MWTP	1600.0	0.1%	0.00E+00		0.00	8000.0	
7	3	3	City of Milford	640.0	0.0%	0.00E+00		0.00	8000.0	
8	3	4	Geary Cnty Sewer	126.9	0.0%	0.00E+00		0.00	15860.0	
PRECIPITATION				43911.0	2.0%	4.82E+06	0.0%	0.05	860.5	697.0
TRIBUTARY INFLOW				2165366.0	97.9%	1.14E+12	100.0%	0.49	2716.1	92.4
POINT-SOURCE INFLOW				2366.9	0.1%	0.00E+00		0.00	8218.3	
***TOTAL INFLOW				2211644.0	100.0%	1.14E+12	100.0%	0.48	2606.4	94.1
GAUGED OUTFLOW				1044892.5	47.2%	6.36E+11		0.76	1376.7	
ADVECTIVE OUTFLOW				7926.8	0.4%	5.10E+11		10.00	1376.7	0.3
***TOTAL OUTFLOW				1052819.3	47.6%	7.46E+11		0.82	1376.7	44.8
***RETENTION				1158824.8	52.4%	5.52E+11		0.64		

Overflow Rate (m/yr)	12.1	Nutrient Resid. Time (yrs)	0.3588
Hydraulic Resid. Time (yrs)	0.6052	Turnover Ratio	2.8
Reservoir Conc (mg/m3)	1715	Retention Coef.	0.524

Milford Lake, TMDL BATHTUB

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.81	0.0
Evaporation (m)	1.33	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	10	0.10
Total N	697	0.05
Ortho P	10	0.10
Inorganic N	697	0.05

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	2	2ND ORDER, DECAY
Nitrogen Balance	1	2ND ORDER, AVAIL N
Chlorophyll-a	1	P, N, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	2	CONCENTRATIONS
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Riverine	2	1	10	2.5	8.3	2.5	0.12	0	0	1.05	0	0	0	0	0	0	0
2	Upper Pool	3	1	16	4.5	6.2	4.2	0.12	0	0	0.08	0	0	0	0	0	0	0
3	Mid Pool	4	1	20	8.6	17.7	6.3	0.12	0	0	0.84	0	0	0	0	0	0	0
4	Main Basin	0	1	14	12	7.3	7.2	0.12	0	0	0.08	0	0	0	0	0	0	0
5	Coves	4	1	3	8.6	6.1	6.1	0	0	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	450	0.3	2980	0.7	58	0.6	0.4	0.7	2440	0.7	250	0.3	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	260	0.3	1410	0.7	19.8	0.6	0.75	0.7	940	0.7	60	0.3	0	0	0	0
4	0	0	210	0.3	1270	0.2	28.3	0.9	1.44	0.2	860	0.2	50	0.3	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
4	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
5	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Republican R	1	1	22917	695	0.5	0	0	88.9	0.12	350.4	0.16	35.5	0.5	212.4	0.15
2	Timber Cr	2	1	153	20.72	0.5	0	0	42	0.5	159.6	0.5	16.8	0.5	96	0.5
3	Rush Cr	3	1	28.13	4.51	0.5	0	0	42	0.5	159.6	0.5	16.8	0.5	96	0.5
4	Milford Outflow	4	4	0	759	0.5	0	0	210	0	1270	0	160	0	410	0
5	Unnamed Tribs	3	1	331	77	0.5	0	0	42	0.5	159.6	0.5	16.8	0.5	96	0.5
6	Wakefield MWTP	2	3	0	0.2	0	0	0	2000	0	8000	0	200	0	800	0
7	City of Milford	3	3	0	0.08	0	0	0	2000	0	8000	0	200	0	800	0
8	Geary Cnty Sewer	4	3	0	0.008	0	0	0	2170	0	15860	0	217	0	1586	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	2.164	0.45
Total Nitrogen	1.525	0.55
Chl-a Model	1.118	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Milford Lake, TMDL BATHTUB

Segment:	6	Area-Wtd Mean				
	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	83.3	0.49	73.0%	287.3	0.30	97.7%
TOTAL N MG/M3	427.7	0.56	9.2%	1722.3	0.58	80.1%
C.NUTRIENT MG/M3	22.2	0.79	27.7%	118.9	0.50	93.4%
CHL-A MG/M3	9.9	0.87	52.6%	31.2	0.69	94.0%
SECCHI M	2.0	0.54	78.3%	0.9	0.44	40.0%
ORGANIC N MG/M3	417.9	0.48	40.3%	1255.5	0.59	97.2%
TP-ORTHO-P MG/M3	24.7	0.64	42.0%	100.0	0.30	89.7%
ANTILOG PC-1	156.6	1.30	36.6%	1948.8	0.42	94.3%
ANTILOG PC-2	10.4	0.18	82.1%	10.7	0.38	83.5%
(N - 150) / P	3.5	1.00	1.0%	5.3	0.42	4.4%
INORGANIC N / P	0.5	3.23	0.0%	2.5	1.68	0.6%
TURBIDITY 1/M	0.5		38.9%	0.5		38.9%
ZMIX * TURBIDITY	2.3	0.09	34.9%	2.3	0.09	34.9%
ZMIX / SECCHI	3.6	0.32	31.2%	6.8	0.42	73.1%
CHL-A * SECCHI	19.6	0.30	82.2%	25.0	0.57	89.7%
CHL-A / TOTAL P	0.1	0.98	23.7%	0.1	0.47	17.0%
FREQ(CHL-a>10) %	36.3	1.30	52.6%	87.4	0.16	94.0%
FREQ(CHL-a>20) %	8.4	2.46	52.6%	56.9	0.43	94.0%
FREQ(CHL-a>30) %	2.4	3.29	52.6%	35.9	0.59	94.0%
FREQ(CHL-a>40) %	0.8	3.93	52.6%	23.5	0.70	94.0%
FREQ(CHL-a>50) %	0.3	4.46	52.6%	15.8	0.81	94.0%
FREQ(CHL-a>60) %	0.1	4.91	52.6%	11.0	0.94	94.0%
CARLSON TSI-P	67.3	0.10	73.0%	85.2	0.03	97.7%
CARLSON TSI-CHLA	52.7	0.16	52.6%	63.4	0.06	94.0%
CARLSON TSI-SEC	52.8	0.12	21.7%	63.2	0.08	60.0%

Milford Lake, TMDL BATHTUB

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Republican R	22917.0	695.0	1.21E+05	0.50	0.03
2	1	2	Timber Cr	153.0	20.7	1.07E+02	0.50	0.14
3	1	3	Rush Cr	28.1	4.5	5.09E+00	0.50	0.16
4	4	4	Milford Outflow		759.0	1.44E+05	0.50	
5	1	3	Unnamed Tribs	331.0	77.0	1.48E+03	0.50	0.23
6	3	2	Wakefield MWTP		0.2	0.00E+00	0.00	
7	3	3	City of Milford		0.1	0.00E+00	0.00	
8	3	4	Geary Cnty Sewer		0.0	0.00E+00	0.00	
PRECIPITATION				63.0	51.0	0.00E+00	0.00	0.81
TRIBUTARY INFLOW				23429.1	797.2	1.22E+05	0.44	0.03
POINT-SOURCE INFLOW					0.3	0.00E+00	0.00	
***TOTAL INFLOW				23492.1	848.5	1.22E+05	0.41	0.04
GAUGED OUTFLOW					759.0	1.44E+05	0.50	
ADVECTIVE OUTFLOW				23492.1	5.8	2.66E+05	9.99	0.00
***TOTAL OUTFLOW				23492.1	764.8	1.22E+05	0.46	0.03
***EVAPORATION					83.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted — **Outflow & Reservoir Concentrations**
Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Republican R	61785.5	91.8%	1.01E+09	99.4%	0.51	88.9	2.7
2	1	2	Timber Cr	870.2	1.3%	3.79E+05	0.0%	0.71	42.0	5.7
3	1	3	Rush Cr	189.4	0.3%	1.79E+04	0.0%	0.71	42.0	6.7
4	4	4	Milford Outflow	52649.8		1.44E+09		0.72	69.4	
5	1	3	Unnamed Tribs	3234.0	4.8%	5.23E+06	0.5%	0.71	42.0	9.8
6	3	2	Wakefield MWTP	400.0	0.6%	0.00E+00		0.00	2000.0	
7	3	3	City of Milford	160.0	0.2%	0.00E+00		0.00	2000.0	
8	3	4	Geary Cnty Sewer	17.4	0.0%	0.00E+00		0.00	2170.0	
PRECIPITATION				630.0	0.9%	3.97E+03	0.0%	0.10	12.3	10.0
TRIBUTARY INFLOW				66079.2	98.2%	1.01E+09	100.0%	0.48	82.9	2.8
POINT-SOURCE INFLOW				577.4	0.9%	0.00E+00		0.00	2004.7	
***TOTAL INFLOW				67286.5	100.0%	1.01E+09	100.0%	0.47	79.3	2.9
GAUGED OUTFLOW				52649.8	78.2%	1.44E+09		0.72	69.4	
ADVECTIVE OUTFLOW				399.4	0.6%	1.29E+09		10.00	69.4	0.0
***TOTAL OUTFLOW				53049.2	78.8%	1.61E+09		0.76	69.4	2.3
***RETENTION				14237.3	21.2%	7.37E+08		1.91		

Overflow Rate (m/yr)	12.1	Nutrient Resid. Time (yrs)	0.5727
Hydraulic Resid. Time (yrs)	0.6052	Turnover Ratio	1.7
Reservoir Conc (mg/m3)	83	Retention Coef.	0.212

Overall Mass Balance Based Upon Predicted — **Outflow & Reservoir Concentrations**
Component: TOTAL N

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Republican R	243528.0	79.6%	1.63E+10	99.5%	0.52	350.4	10.6
2	1	2	Timber Cr	3306.9	1.1%	5.47E+06	0.0%	0.71	159.6	21.6
3	1	3	Rush Cr	719.8	0.2%	2.59E+05	0.0%	0.71	159.6	25.6
4	4	4	Milford Outflow	311726.0		5.47E+10		0.75	410.7	
5	1	3	Unnamed Tribs	12289.2	4.0%	7.55E+07	0.5%	0.71	159.6	37.1
6	3	2	Wakefield MWTP	1600.0	0.5%	0.00E+00		0.00	8000.0	
7	3	3	City of Milford	640.0	0.2%	0.00E+00		0.00	8000.0	
8	3	4	Geary Cnty Sewer	126.9	0.0%	0.00E+00		0.00	15860.0	
PRECIPITATION				43911.0	14.3%	4.82E+06	0.0%	0.05	860.5	697.0
TRIBUTARY INFLOW				259843.9	84.9%	1.64E+10	100.0%	0.49	325.9	11.1
POINT-SOURCE INFLOW				2366.9	0.8%	0.00E+00		0.00	8218.3	
***TOTAL INFLOW				306121.8	100.0%	1.64E+10	100.0%	0.42	360.8	13.0
GAUGED OUTFLOW				311726.0	101.8%	5.47E+10		0.75	410.7	
ADVECTIVE OUTFLOW				2364.8	0.8%	4.50E+10		10.00	410.7	0.1
***TOTAL OUTFLOW				314090.8	102.6%	5.43E+10		0.74	410.7	13.4
***RETENTION				-7969.0		3.10E+10		10.00		

Overflow Rate (m/yr)	12.1	Nutrient Resid. Time (yrs)	0.6466
Hydraulic Resid. Time (yrs)	0.6052	Turnover Ratio	1.5
Reservoir Conc (mg/m3)	428	Retention Coef.	-0.026

Appendix B – Conversion to Daily Load, Daily Load Calculations for BATHTUB

The TMDL has estimated annual average loads for TN and TP that if achieved should meet the water quality targets. A recent court decision often referred to a sthe "Anacostia decision" has dicated that TMDLs include a "daily" load (Friend of the Earth, Inc. v. EPA, et al.).

Expressing this TMDL in daily time steps could be misleading to imply a daily response to a daily load. It is important to recognize that the growing season mean chlorophyll *a* is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

To translate long-term averages to maximum daily load values, EPA Region 7 has suggested the approach described in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001)(TSD).

Maximum Daily Load (MDL) = (Long-Term Average Load) * $e^{[Z\sigma - 0.5\sigma^2]}$

where $\sigma^2 = \ln\left(CV^2 + 1\right)$

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99th percentile probability basis

LTA= Long Term Average

MOS= Margin of Safety

Parameter	LTA	CV	$e^{[Z\sigma - 0.5\sigma^2]}$	TMDL
Total P	148,341.2 lbs/yr	0.3	1.90	772.19 lbs/day
Total N	674,882.2 lbs/yr	0.2	1.55	2865.9 lbs/day

Maximum Daily Load Calculation

Annual Total P Load = 148,341.2 lbs/yr

Maximum Daily P Load $=[(148{,}341.2 \text{ lbs/yr})/(365\text{days/yr})]*e^{[2.326*(0.294)-0.5*(0.294)^2]}$
$= 772$ lbs/day

Annual Total N Load = 674,882.2 lbs/yr

Maximum Daily N Load $= [(674{,}882.2 \text{ lbs/yr})/(365 \text{ days/yr})]*e^{[2.326*(0.198)-0.5*(0.198)^2]}$
$= 2866$ lbs/day

Source- *Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001)*

Appendix C. Confined Animal Feeding Operations within the Milford Lake Watershed.

PER_PERMIT	FAC_COUNTY	ANI_TOTAL_	PERMIT_ANI	PERMIT_A_1	WLA
826 (Application)	CD	300	Beef	0-299	0
A-LRCD-BA02	CD	750	Beef	300-999	0
A-LRCD-BA07	CD	290	Beef	0-299	0
A-LRCD-BA09	CD	800	Beef	300-999	0
A-LRCD-BA06	CD	575	Beef	300-999	0
A-LRCD-BA01	CD	600	Beef	300-999	0
A-LRCD-BA08	CD	290	Beef	0-299	0
A-LRCD-BA04	CD	300	Beef	300-999	0
A-LRCD-BA03	CD	400	Beef	300-999	0
A-LRCD-MA04	CD	50	Dairy	0-299	0
A-LRCD-MA02	CD	60	Dairy	0-299	0
A-LRCD-B002	CD	999	Beef	300-999	0
A-LRCD-B001	CD	999	Beef	300-999	0
A-LRCD-S009	CD	1800	Swine	Swine300-999	0
A-LRCD-S006	CD	1000	Swine	Swine0-299	0
A-LRCD-H002	CD	3600	Swine	Swine1000-3724	0
A-LRCD-H003	CD	3600	Swine	Swine1000-3724	0
A-LRCD-S007	CD	776	Swine,Beef	Swine0-299,0-299	0
A-LRCY-BA09	CY	150	Beef	0-299	0
A-LRCY-BA04	CY	500	Beef	300-999	0
A-LRCY-BA61	CY	120	Beef	0-299	0
A-LRCY-BA35	CY	400	Beef	300-999	0
A-LRCY-BA21	CY	200	Beef	0-299	0
A-LRCY-BA22	CY	250	Beef	0-299	0
A-LRCY-BA44	CY	200	Beef	0-299	0
A-LRCY-BA56	CY	225	Beef	0-299	0
A-LRCY-BA43	CY	325	Beef	300-999	0
A-LRCY-BA57	CY	50	Beef	0-299	0
A-LRCY-BA42	CY	175	Beef	0-299	0
A-LRCY-BA17	CY	150	Beef	0-299	0
A-LRCY-BA50	CY	80	Beef	0-299	0
A-LRCY-BA66	CY	448	Beef	300-999	0
A-LRCY-BA10	CY	400	Beef	300-999	0
A-LRCY-BA15	CY	100	Beef	0-299	0
A-LRCY-BA46	CY	125	Beef	0-299	0
A-LRCY-BA49	CY	50	Beef	0-299	0
A-LRCY-BA51	CY	80	Beef	0-299	0

A-LRCY-BA28	CY	150	Beef	0-299	0
A-LRCY-BA18	CY	130	Beef	0-299	0
A-LRCY-BA64	CY	60	Beef	0-299	0
A-LRCY-BA48	CY	60	Beef	0-299	0
A-LRCY-BA32	CY	550	Beef	300-999	0
A-LRCY-BA54	CY	500	Beef	300-999	0
A-LRCY-BA45	CY	500	Beef	300-999	0
A-LRCY-BA67	CY	765	Beef	300-999	0
A-LRCY-BA29	CY	200	Beef	0-299	0
A-LRCY-BA26	CY	200	Beef	0-299	0
A-LRCY-BA38	CY	10	Beef	0-299	0
A-LRCY-BA47	CY	130	Beef	0-299	0
A-LRCY-BA25	CY	200	Beef	0-299	0
A-LRCY-BA40	CY	70	Beef	0-299	0
A-LRCY-BA58	CY	250	Beef	0-299	0
A-LRCY-BA37	CY	150	Beef	0-299	0
A-LRCY-BA60	CY	700	Beef	300-999	0
A-LRCY-BA59	CY	250	Beef	0-299	0
A-LRCY-BA53	CY	600	Beef	300-999	0
A-LRCY-BA65	CY	120	Beef	0-299	0
A-LRCY-BA70	CY	200	Beef	0-299	0
A-LRCY-BA52	CY	600	Beef	300-999	0
A-LRCY-BA24	CY	200	Beef	0-299	0
A-LRCY-BA19	CY	50	Beef	0-299	0
A-LRCY-BA30	CY	275	Beef	0-299	0
A-LRCY-BA12	CY	250	Beef	0-299	0
A-LRCY-BA11	CY	250	Beef	0-299	0
A-LRCY-BA31	CY	150	Beef	0-299	0
A-LRCY-BA68	CY	100	Beef	0-299	0
A-LRCY-BA14	CY	250	Beef	0-299	0
A-LRCY-BA71	CY	250	Beef	0-299	0
A-LRCY-BA36	CY	125	Beef	0-299	0
A-LRCY-BA27	CY	350	Beef	300-999	0
A-LRCY-BA20	CY	100	Beef	0-299	0
A-LRCY-BA16	CY	150	Beef	0-299	0
A-LRCY-BA13	CY	100	Beef	0-299	0
A-LRCY-BA69	CY	50	Beef	0-299	0
A-LRCY-BA39	CY	150	Beef	0-299	0
A-LRCY-BA55	CY	300	Beef	300-999	0
A-LRCY-BA41	CY	80	Beef	0-299	0
A-LRCY-BA62	CY	200	Beef	0-299	0
A-LRCY-BA72	CY	100	Beef	0-299	0
A-LRCY-BA02	CY	250	Beef	0-299	0
A-LRCY-BA05	CY	250	Beef	0-299	0
A-LRCY-BA03	CY	250	Beef	0-299	0

A-LRCY-BA33	CY	250	Beef	0-299	0
A-LRCY-BA34	CY	100	Beef	0-299	0
A-LRCY-BA63	CY	100	Beef	0-299	0
A-LRCY-BA08	CY	450	Beef,Swine	0-299,Swine0-299	0
A-LRCY-MA02	CY	50	Dairy	0-299	0
A-LRCY-MA03	CY	30	Dairy	0-299	0
A-LRCY-EA03	CY	300	Exotic	Exotic0-999999	0
A-LRCY-SA05	CY	250	Swine	Swine0-299	0
A-LRCY-SA04	CY	500	Swine	Swine0-299	0
A-LRCY-SA07	CY	950	Swine	Swine300-999	0
A-LRCY-SA06	CY	50	Swine	Swine0-299	0
A-LRCY-SA03	CY	357	Swine	Swine0-299	0
A-LRCY-B001	CY	450	Beef	300-999	0
A-LRCY-B009	CY	650	Beef	300-999	0
A-LRCY-B008	CY	300	Beef	300-999	0
A-LRCY-B005	CY	280	Beef	0-299	0
A-LRCY-B006	CY	299	Beef	0-299	0
A-LRCY-M005	CY	180	Dairy	0-299	0
A-LRCY-P001	CY	79000	Laying Hens NL	300-999	0
A-LRCY-S043	CY	750	Swine	Swine0-299	0
A-LRCY-S056	CY	3149	Swine	Swine300-999	0
A-LRCY-H004	CY	3900	Swine	Swine1000-3724	0
A-LRCY-S050	CY	3645	Swine	Swine300-999	0
A-LRCY-S012	CY	1404	Swine	Swine300-999	0
A-LRCY-S013	CY	1574	Swine	Swine300-999	0
A-LRCY-S022	CY	1920	Swine	Swine300-999	0
A-LRCY-S054	CY	1866	Swine,Beef	Swine300-999,0-299	0
A-LRCY-B010	CY	500	Swine,Beef	Swine0-299,300-999	0
A-LRCY-S031	CY	2218	Swine,Beef	Swine300-999,0-299	0
A-LRCY-S023	CY	2390	Swine,Beef	Swine300-999,0-299	0
A-LRCY-BA73	CY	350	Beef	0-299	0
A-LRCY-B004	CY	180	Beef	0-299	0
A-LRCY-B007	CY	160	Beef	0-299	0
A-LRCY-B002	CY	300	Beef	0-299	0
A-LRCY-B003	CY	92	Beef,Horses,Goats,Sheep	0-299,0-299,0-299,0-299	0
A-LRCY-M004	CY	126	Dairy	0-299	0
A-LRCY-S037	CY	2464	Swine,Beef	Swine300-999,0-299	0

A-LRCY-S017	CY	1970	Swine,Beef	Swine300-999,0-299	0
A-LRDK-BA01	DK	200	Beef	0-299	0
N-LRGE-5696	GE	275	Beef	0-299	0
A-LRGE-BA01	GE	400	Beef	300-999	0
A-LRGE-M001	GE	200	Dairy	0-299	0
A-LRJW-BA04	JW	100	Beef	0-299	0
A-LRJW-BA11	JW	205	Beef	0-299	0
A-LRJW-BA06	JW	200	Beef	0-299	0
A-LRJW-BA08	JW	600	Beef	300-999	0
A-LRJW-BA01	JW	250	Beef	0-299	0
A-LRJW-BA07	JW	600	Beef	300-999	0
A-LRJW-BA02	JW	200	Beef	0-299	0
A-LRJW-MA01	JW	40	Dairy	0-299	0
A-LRJW-B005	JW	400	Beef	300-999	0
A-LRJW-B006	JW	999	Beef	300-999	0
A-LRJW-S023	JW	1168	Swine,Beef	Swine0-299,300-999	0
A-LRRL-S001	RL	1676	Swine	Swine300-999	0
A-KSRL-S001	RL	1320	Swine,Beef	Swine300-999,0-299	0
A-KSRL-S003	RL	860	Swine,Beef	Swine0-299,0-299	0
1021 (Application)	RP	500	Beef	300-999	0
A-LRRP-BA06	RP	200	Beef	0-299	0
A-LRRP-BA05	RP	450	Beef	300-999	0
A-LRRP-BA03	RP	300	Beef	300-999	0
A-LRRP-BA07	RP	240	Beef	0-299	0
A-LRRP-MA01	RP	25	Dairy	0-299	0
A-LRRP-MA02	RP	25	Dairy	0-299	0
A-LRRP-LA01	RP	1600	Sheep,Beef	0-299,0-299	0
A-LRRP-C002	RP	3000	Beef	1000-9999	0
A-LRRP-B002	RP	999	Beef	300-999	0
A-LRRP-B004	RP	999	Beef	300-999	0
A-LRRP-B005	RP	998	Beef	300-999	0
A-LRRP-C001	RP	25000	Beef	10000-999999	0
A-LRRP-B001	RP	999	Beef	300-999	0
A-LRRP-B003	RP	999	Beef	300-999	0
A-LRRP-S025	RP	720	Swine	Swine0-299	0
824 (Application)	RP	651	Beef	300-999	0
A-LRWS-S038	WS	2490	Swine	Swine300-999	0
A-LRWS-BA04	WS	150	Beef	0-299	0
A-LRWS-MA01	WS	50	Dairy	0-299	0

A-LRWS-B003	WS	999	Beef	300-999	0
A-LRWS-D001	WS	1900	Dairy	1000-9999	0
A-LRWS-S028	WS	2770	Swine	Swine300-999	0
A-BBWS-H005	WS	7200	Swine	Swine1000-3724	0
A-LRWS-S032	WS	2400	Swine	Swine300-999	0
A-LRWS-S031	WS	2400	Swine	Swine300-999	0
A-LRWS-H006	WS	4800	Swine	Swine1000-3724	0
A-LRWS-S030	WS	2400	Swine	Swine300-999	0
A-LRWS-S036	WS	2400	Swine	Swine300-999	0
A-LRWS-S035	WS	2400	Swine	Swine300-999	0
A-LRWS-S029	WS	4450	Swine	Swine300-999	0
A-LRWS-S034	WS	2400	Swine	Swine300-999	0
A-LRWS-H002	WS	14522	Swine	Swine1000-3724	0
A-LRWS-H005	WS	3940	Swine	Swine1000-3724	0
A-LRWS-H001	WS	5675	Swine	Swine1000-3724	0
A-LRWS-H007	WS	8000	Swine	Swine1000-3724	0
A-LRWS-S024	WS	2400	Swine	Swine300-999	0
A-LRWS-S018	WS	275	Swine,Beef	Swine0-299,0-299	0
A-LRWS-B002	WS	1500	Swine,Beef	Swine300-999,300-999	0
A-LRWS-BA05	WS	999	Beef	300-999	0
A-LRWS-B001	WS	302	Beef,Horses	0-299,0-299	0
A-LRWS-H009	WS	4800	Swine	Swine1000-3724	0
A-LRWS-S033	WS	2400	Swine	Swine300-999	0
A-LRWS-H008	WS	8000	Swine	Swine1000-3724	0
A-LRWS-S023	WS	1270	Swine	Swine300-999	0
A-LRWS-S013	WS	535	Swine,Beef	Swine0-299,0-299	0

Appendix D. NPDES Facilities within the Milford Lake Watershed.

PERM_NO	FAC_NAME	NPDES_NO	Permit Expires	TP WLA (lbs/day)	TN WLA (lbs/day)
C-LR05-NO02	HAWKS LANDING MOBILE HOME PARK	KSJ000557	10/31/2014	0.0	0.0
C-LR17-NO03	MILLER MOBILE HOME PARK	KSJ000558	12/31/2014	0.0	0.0
C-LR17-NO04	THUNDERBIRD MARINA	KSJ000637	12/31/2014	0.0	0.0
I-LR01-NP01	BOETTCHER ENTERPRISES, INC.	KSJ000618	10/31/2014	0.0	0.0
I-LR03-PR01	ABRAM READY MIX, INC.-BELLEVILLE PLANT	KSG110084	9/30/2017	0.0	0.0
I-LR05-CO02	CLAY CENTER POWER PLANT	KS0093459	2/28/2017	0.0	0.0
I-LR05-PO01	VALLEY FERTILIZER	KS0090018	12/31/2014	0.0	15.3
I-LR05-PO02	CLAY CENTER GROUNDWATER REMED PWS 2	KS0093351	2/28/2017	0.0	0.0
I-LR05-PO04	CLAY CENTER WATER TREATMENT PLANT	KS0098477	12/31/2012	0.0	0.0
I-LR05-PR01	MIDWEST PRODUCTS - CLAY CENTER PLANT	KSG110172	9/30/2017	0.0	0.0
I-LR05-PR02	MIDWEST PRODUCTS-CLAY CENTER (NEW)	KSG110216	9/30/2017	0.0	0.0
I-LR06-NO03	MID-KANSAS ELECTRIC / CLIFTON STATION	KSJ000500	3/31/2014	0.0	0.0
I-LR08-PO02	CLOUD CERAMICS - #C-77 & #C-80	KS0002682	12/31/2017	0.0	0.0
I-LR08-PR01	CONCORDIA READY-MIX	KSG110064	9/30/2017	0.0	0.0
I-LR08-PR02	ABRAM READY MIX, INC. - CONCORDIA PLANT	KSG110080	9/30/2017	0.0	0.0
I-LR14-PR01	MIDWEST PRODUCTS - LINN PLANT	KSG110135	9/30/2017	0.0	0.0
I-LR15-PR02	PENNY'S CONCRETE - HWY 57 PLANT, J.C.	KSG110170	9/30/2017	0.0	0.0
I-LR17-PO02	BAYER CONSTRUCTION (PS QRY)	KS0090891	4/30/2015	0.0	0.0
I-LR22-PO01	NESIKA ENERGY, LLC - ETHANOL PLANT	KS0096539	12/31/2016	0.3	5.5
I-LR24-PO03	BAYER CONSTRUCTION - MARTIN QUARRY	KS0098043	12/31/2015	0.0	0.0
M-LR01-NO01	AGENDA, CITY OF	KSJ000378	5/31/2014	0.0	0.0
M-LR02-NO01	AURORA, CITY OF	KSJ000379	12/31/2016	0.0	0.0
M-LR03-OO01	BELLEVILLE, CITY OF	KS0027529	6/30/2015	5.0	26.7
M-LR05-OO01	CLAY CENTER, CITY OF	KS0048399	6/30/2015	9.0	47.8
M-LR06-OO01	CLIFTON, CITY OF	KS0048437	6/30/2012	2.0	8.1
M-LR07-OO01	CLYDE, CITY OF	KS0022403	12/31/2015	1.4	5.8
M-LR08-OO01	CONCORDIA, CITY OF	KS0025577	6/30/2015	16.9	90.2
M-LR09-OO01	COURTLAND, CITY OF	KS0083399	3/31/2015	0.9	3.5
M-LR10-NO01	FORMOSO, CITY OF	KSJ000371	4/30/2014	0.0	0.0
M-LR11-NO01	GREEN, CITY OF	KSJ000372	4/30/2014	0.0	0.0
M-LR12-NO01	JAMESTOWN, CITY OF	KSJ000373	4/30/2014	0.0	0.0
M-LR13-NO01	JEWELL, CITY OF	KSJ000374	4/30/2014	0.0	0.0
M-LR14-NO01	LINN, CITY OF	KSJ000375	4/30/2014	0.0	0.0
M-LR15-OO04	GEARY COUNTY SEWER DISTRICT #4	KS0079197	6/30/2015	0.2	1.1
M-LR16-OO02	MANKATO, CITY OF	KS0095231	3/31/2015	2.3	9.1
M-LR17-NO02	KDWP - MILFORD STATE PARK WWTF	KSJ000376	7/31/2014	0.0	0.0
M-LR17-OO01	MILFORD, CITY OF	KS0086231	3/31/2015	1.0	3.9
M-LR18-OO01	MORGANVILLE, CITY OF	KS0024678	6/30/2015	0.3	1.3
M-LR19-NO01	PALMER, CITY OF	KSJ000365	10/31/2014	0.0	0.0
M-LR20-NO01	RANDALL, CITY OF	KSJ000366	1/31/2014	0.0	0.0
M-LR21-NO01	REPUBLIC, CITY OF	KSJ000367	4/30/2014	0.0	0.0
M-LR22-NO01	SCANDIA, CITY OF	KSJ000368	3/31/2014	0.0	0.0
M-LR24-OO01	WAKEFIELD MWTP	KS0027545	9/30/2016	2.4	9.4
P-LR05-IO02	HUTCHINSON-MAYRATH-DIV OF GLOBAL INDUST	KSP000052	12/31/2013	0.0	0.0